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CURRENT DEVELOPMENTS IN COAL

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(49804)

CONTENTS

ILLUSTRATIONS

CURRENT DEVELOPMENTS IN COAL

FUEL OIL AS A COMPETITIVE FACTOR IN THE DOMESTIC FUEL MARKET*

By

W. Y. Wildman

Managing Director, Illinois Coal Traffic Bureau, Chicago

An intelligent study of the question, "Competition of Fuel Oil and Coal in the Domestic Market," calls for a division of the subject matter into three natural parts; (1) competition as it was in the past; (2) as it is now; and (3) as we can expect it to be in the future.

COMPETITION IN THE PAST

The oil burner, which originally was of the conversion type, first became an important factor in the domestic heating field about the time of the World War. Initially, it met with indifferent success, as burners were not only expensive but generally noisy, sometimes odorous, and frequently got out of order. Coal prices were high, however, and as the burners offered automatic heat, which was an innovation, except in those localities where cheap natural gas was available, they became increasingly popular as a result of an intensive advertising and selling drive. This was particularly true in the boom years ending with 1929. In the meantime, of course, reduction in price and improvement in design added to the oil burner's popularity. Up until this time, coal could not put up any argument against oil except that of economy, and the majority of installations were made in homes where the owner felt perfectly willing to pay the difference in cost in order that he might secure the convenience of automatic heat.

It is probably true that in this middle western region, a majority of the homes in which oil burners have been installed, previously burned anthracite coal, coke, or a high grade eastern bituminous coal. A relatively small number were burning a medium grade bituminous coal such as mined here in Illinois, and consequently, the Illinois producer has not suffered to any great extent because of oil competition in the domestic field. From 1930 to 1932, oil burner sales fell off, as might be expected, but shortly afterwards again gained impetus with the result that sales in 1936 were by far the largest

* This paper has been published since the Conference in Coal-Heat, vol. 32, no. 4, p. 28, 1937; The Black Diamond, vol. 99, No. 10, pp. 27-28, 1937, and in the Northwest Coal Dealer, number unknown.

in history. This showing was made in spite of heavy sales of gas conversion burners here in the West, and in spite of a new and formidable competitor in the field—the domestic stoker. This brings us up to a discussion of the competition of fuel oil and coal under present conditions.

COMPETITION AT THE PRESENT

According to reports of the Bureau of Census, there are 11,294,603 one and two family homes in the United States equipped with central heating plants at the present time, and on January 1, 1937, there were 1,349,401 domestic oil burners in use. One company alone, advertises total sales of 250,000 units. On the above basis, it will be found that one out of every 8.4 centrally heated houses in the country is heated with oil. Assuming an average coal consumption of twelve tons to the home per annum, it will be seen that the domestic oil burner is responsible for the displacement of over 16,000,000 tons of coal or its derivative, coke. For reasons hereinafter outlined, the Middle West has always been an excellent market for automatic heating devices of all kinds. In the five states of Illinois, Iowa, Missouri, Wisconsin, and Minnesota, comprising the principal market for Illinois coal, on January 1, 1937 there were 305,775 domestic oil burner installations in the 2,155,758 one and two-family urban homes which are equipped with central heating plants. This is a ratio of one to seven as against one to 8.4 for the country as a whole.

Again using the purely arbitrary figure of twelve tons per annum to the home, it will be found that the equivalent coal consumption amounts to over 3,600,000 tons annually. According to reports of the United States Bureau of Mines, the consumption of heating oils in the State of Illinois alone, in the year 1935, amounted to 8,324,000 barrels. This exceeded by far the consumption in any other state in the Union, except New York. On a heat basis, measured by British thermal units, a ton of coal is equivalent to four barrels of oil. Using that figure the heating oil consumption of Illinois in 1935 was equivalent to 2,081,000 tons of Illinois coal. For the five states of Illinois, Iowa, Missouri, Minnesota, and Wisconsin, the consumption of heating oils in 1935 amounted to 15,200,000 barrels, or the equivalent of 3,800,000 tons of coal. Unquestionably, the consumption in 1937 will be considerably greater because of new installations made since 1935.

The producer of coal, and especially the Illinois producer, is not so much concerned over losses of tonnage in the past as he is in holding his present market, and if possible, increasing it in the future. Competitive conditions have changed very materially in the last two or three years as a result of great improvements made in the small domestic stoker. Up until the time that the domestic stoker emerged from the experimental stage into a commercially practical automatic heating device, coal could offer no argument against oil except that of economy. Now, however, coal promises to soon become the dominant factor in the automatic domestic heating field. The stoker has taken the country by storm, and sales are continuing to increase at a rate that is most gratifying to the coal people. According to Bureau of Census reports, the sale of small sized domestic stokers using up to 60 pounds of coal to the hour amounted to 6,783 units in 1932; 14,212 units in 1933; 23,214 units in 1934; 41,126 units in 1935; and 76,376 units in 1936. Sales for the first eight months of 1937 were 43.4 per cent over sales for the corresponding period of 1936, so a total of over 100,000 units for the full year can reasonably be expected. On this basis, there will be a total of 261,711 units in use on January 1, 1938 that are less than six years old. As stated before, oil burner sales in 1936 were the largest in the history of industry; but let us look at the changing ratio of oil burner sales to domestic stoker sales. In 1932, the sale of conversion oil burners outnumbered domestic stoker sales by 10 to 1; in 1933, by 6 to 1; in 1934, by 4 to 1; in 1935, by 3.2 to 1; and in 1936, by 2.9 to 1. If stoker sales hold up for the balance of 1937, as well as they did for the eight months ending August 31, sales for the year will aggregate 109,523 units. The sale of oil conversion units in the first six months of 1937 exceeded those for the corresponding period of 1936 by 37.9 per cent. At the same rate of increase, sales for the full year of 1937 will amount to 270,306 units. On this basis, the sale of oil conversion units for the country as a whole in 1937, will outnumber the sale of domestic stoker units by a ratio of 2.5 to 1. The probabilities are that the ratio would be very much less in the Middle West, as this area is losing ground as a market for oil burners as compared with the country as a whole, but it's the most fertile ground for domestic stoker sales. Although total oil burner sales for the country increased 49.3 per cent in 1936 over 1929, sales in representative key markets in the Middle West increased only 35 per cent over 1929.

There are five principal factors that normally would influence one in the choice of a fuel and a method of firing, namely,—dependability, cleanliness, convenience, noise, and economy.

From the standpoint of dependability, there can be little choice between fuel oil and coal, both are dependable. Chances of a failure of supply of either fuel are quite romote. From the standpoint of cleanliness, oil might be preferred to coal burned in a hand fed boiler, but would have no advantage over coal burned in a domestic stoker. Modern stoker coal is dustless and is burned practically without smoke. There is some oil film that permeates the house and the neighbor's house as well with most oil burners. From the standpoint of convenience, oil holds a big advantage over hand fired coal, but only a slight advantage over coal burned in a stoker, and particularly, in a stoker of the bin food type. From the standpoint of noise, there would be little difference either way, the balance probably being in favor of coal. From the standpoint of economy, coal's position is far in front.

The best grades of southern Illinois stoker coals now sell in the Chicago market at $6.30 a ton in four ton lots, and $5.75 a ton in 100 ton lots. Fuel oil suitable for use in the average oil burner sells for 7 cents a gallon. In order to make a comparison of relative heat values, it is necessary to reduce both coal and oil to a B.t.u. basis. Southern Illinois stoker coal will average 12,000 B.t.u. to the pound or 24,000,000 to the ton. Based on a price of $6.30 a ton, the consumer of coal receives 38,100 B.t.u. per penny delivered. Ordinary No. 2 fuel oil, the accepted oil for a conversion burner, contains approximately 140,000 B.t.u. per gallon which is equivalent to 20,000 B.t.u. per penny. It is generally agreed that coal can be burned in a modern domestic stoker with approximately the same degree of efficiency as can fuel oil in a conversion burner. On this promise, the present cost of heating a house in Chicago with oil in a conversion burner is 90 per cent greater than the cost of heating with a stoker burning southern Illinois coal. It is safe to assume that the average cost of heating a Chicago home with a conversion oil burner is in the neighborhood of $175.00 a year. The same home could be heated with a modern stoker burning southern Illinois coal for approximately $92.00 a year, or at a saving of $83.00 a year. With a larger house, the saving would be greater, and with a smaller house less.

While, in all fairness, it must be admitted that the electric power cost is somewhat greater with a domestic stoker than with a conversion oil burner, the difference in cost is quite insignificant.

Under the heading of economy, something should be said about the original installation costs. It is probably true that the installation cost of a good stoker is still somewhat higher than the cost of a good conversion burner. The difference, however, is not great, and particularly, on a ten-year amortization basis. Furthermore, with stoker manufacturing increasing in volume the way it is, reductions in stoker prices in the near future can reasonably be expected. Servicing charges on oil burners would probably be as great or greater than on a stoker.

Another factor that should be given some weight is the one of safety. On this score, of course, coal has the better of the argument. An additional argument in favor of coal is the fact that it gives a continuous heat and is generally considered better from a health standpoint than an intermittent heat such as oil or gas. A certain retail coal association, in advertising the merits of coal versus oil or gas, has made much of the point that one gets "layer cake" heat with oil or gas, meaning a wide variation between the floor temperature and the temperature in the zone of a person's head when sitting or standing.

From the standpoint of dependability, cleanliness, and noise there is little choice between the two fuels. Fuel oil has a slight advantage from the standpoint of convenience, but coal holds a tremendous advantage from the standpoint of economy. It therefore resolves itself into this—the man who is deliberating between the choice of a conversion oil burner and a coal stoker must decide whether it is worth $83.00 a year for the slightly greater convenience he secures through the use of an oil burner over that which he would enjoy with a modern stoker. An increasing number of people are becoming convinced that this added convenience is not worth that much, and many of the stoker installations today are replacing the older type conversion oil burner.

COMPETITION IN THE FUTURE

I have made the statement that, in my opinion, coal is destined to be the leading fuel in the automatic heating field in the near future. The popularity of coal, oil, or gas, depends to a great extent on the proximity to supply. In the heart of the great oil and gas fields of the Southwest and Far West, coal will never be very much of a factor so long as the other fuels continue to be available at relatively low prices. The situation is entirely different, however, in the Middle West market where Illinois coals are sold.

No section of the country offers as great a field for automatic heating devices as does the Middle West. This is proven by sales of all types of burners (oil, gas, and coal) during recent years. It is estimated that 46.7 per cent of the stoker installations of the country have been made in the Middle West area. There are two principal reasons for this—first, because 45.2 per cent of American homes with central heating plants are located in this area; and second, because of the tremendous advertising effort that has been put forth here in recent years selling the public on automatic heat. Natural gas is a relatively new fuel in such states as Illinois, Iowa, and Minnesota. During the past five years, the large gas companies have spent millions of dollars advertising gas as the ideal automatic fuel. This has sold many gas burners it is true, but it also has had the effect of making the public at large think in terms of automatic heat. Millions of dollars have also been spent for advertising by the oil burner people, by the stoker manufacturer, and coal people expounding the merits of their product with the same effect of building up "automatic heat consciousness" in the mind of the public. Millions of dollars are now being spent annually for advertising by the coal producers of the country and by the stoker manufacturers in a nationwide advertising campaign which is expected to add further stimulus to stoker sales.

The popularity of either fuel in the future will depend to some extent on the relative costs of coal and oil. Oil prices have not fluctuated very widely during the past six or seven years, the average being very close to seven cents a gallon for the better grades, with a slight tendency upward in recent years. This oil sells for $3\frac{5}{8}$ to $3\frac{3}{4}$ cents a gallon in tank car lots, F.O.B. Group 3, Oklahoma. The transportation cost to Chicago is $0.238 a gallon, making delivered costs slightly over 6 cents a gallon. The retailer's margin is about a cent a gallon. An increase in the price at the refinery of even 25 per cent would increase the retail price only 13 per cent. Some people hold to the thought that with limited crude production and an ever increasing demand for gasoline for motor fuel, it will be necessary to increase the amount of crude distilled through the cracking process which will mean a lesser percentage of fuel oil distilled, and hence higher prices. This is not apt to occur during the next three or four years, but may be a factor after that.

In the distillation of crude oil there are three major products, gasoline, distillate fuel oil, and residual fuel oil. By means of the so called cracking process, it is possible to materially increase the gasoline yield with a resultant decrease in the fuel oil yield. With gasoline selling for upwards of five cents a gallon at the refinery, and fuel oil selling from 2 cents to 4 cents a gallon, it would seem that a refiner would be interested in securing a maximum gasoline yield. To a certain extent this is true, but the refiner is put to considerable additional expense in recharging the fuel oils to the stills under the cracking process, so the higher gasoline yield results in a greater cost per gallon. Domestic fuel oil is fast becoming a major product, and at present prices is a distinct commercial asset to the refiner. Even though more and more crude oil is being refined through the cracking process, with a resultant higher gasoline yield, the percentage of the domestic fuel yield has also increased. In 1930 the domestic fuel oil yield was 8.79 per cent; in 1933, 9.16 per cent; in 1936, 11.80 per cent; and in January 1937, reached 14.14 per cent. The answer is that greater gasoline and heating oil yield has been at the expense of the heavy residual fuel oils which are essentially a by-product and return to the refiner a very small amount per gallon. In 1930, the yield of residual fuel oil per barrel of crude refined was 31.4 per cent, and in 1936, 26.7 per cent.

Another fact that should not be overlooked is that the peak demand for gasoline is in the summer, while the peak demand for domestic fuel oil is in the winter. Refinery operation is very flexible, so it is possible to obtain a higher gasoline yield during the summer months and to obtain less gasoline and more domestic fuel oil during the winter months. For these reasons, the proponents of coal and coal stokers should not place too much reliance on the possibility of increasing fuel oil prices as a major sales argument for their product.

Although the surface has just been scratched in stoker merchandising, results so far are most encouraging and prospects for the future are very bright. The coal producers are cooperating with stoker manufacturers to the fullest extent, and practically every leading operator is now making a specially sized and specially prepared coal for domestic stoker use. To indicate the reception by the trade, one operator alone in the southern Illinois field will sell over 100,000 tons of its special stoker size during 1937. Improvement in stoker design and a lowering of initial installation costs, which should normally result from volume production, will add fuel, and by that I mean solid fuel, to the fire.

In the main, the remarks thus far have been directed to the question of the competition of coal with oil burned in a conversion burner. There are two other forms of oil competition in the domestic field that are becoming increasingly important. The first of these is the self contained oil furnace or boiler used as a central heating unit and the second the so-called space heater. The self contained unit is particularly popular in new homes selling in the higher price bracket. There can be no denying that these burners are doing a nice job and through their greater efficiency of operation will reduce heating costs below those that can be obtained with a conversion burner. About 25,000 of these unit burners were sold last year. However, in spite of their superiority over the conversion burner from the standpoint of efficiency, except in those districts remote from a dependable supply of coal, heating costs with such burners are still considerably in excess over those that may be obtained with solid fuel.

The space heater is a small unit sold in most cases in homes, stores, or shops not equipped with central heating plants. These burners sell at retail from about $50 to $100 each, and are equipped to burn No. 1 fuel oil, a higher and more expensive grade than that ordinarily used in a conversion burner. They are being strongly featured by the larger department stores and mail order houses and are selling quite fast in certain areas. In view of the fact that there are nearly 14,000,000 one- and two-family homes in the country that are not now equipped with central heating plants, to say nothing of the millions of stores, small shops, filling stations and similar structures, this new form of competition is of deep concern to both the coal producer and the retailer. They are wide awake to the situation, however, and fully realize that only through intensive and continual public education on the advantages of solid fuel heating, improvement in heater design and maintenance of coal prices on a fair and equitable basis, can coal hope to hold its place in the sun.

CHANGES IN THE CONSTITUTION OF ILLINOIS COALS THROUGH PREPARATION PROCESSES, AND THE IMPORTANCE OF THESE CHANGES ON UTILIZATION*

By

L. C. McCabe

Associate Geologist, Coal Division, Illinois State Geological Survey

Many of the problems of combustion of Illinois coals are related to the kind and quantity of bands in the coal beds (fig. 1a-d) and in the prepared coal. Such significant characteristics as the ash content, the fusion point of the ash, the swelling, coking, free burning tendencies, friability, grindability, and B.t.u. content are intimately related to the kind of bands making up the fuel.

The physical behavior of these bands in mining, screening and shipping is important. If a number of blocks of coal are examined, it becomes apparent that on the majority of them the surface parallel to the bedding plane is covered with fusain (fig. 1c). This is rather definite proof that the fusain is structurally the weakest member of the four coal components and is primarily responsible for degradation.

Occasionally blocks will be seen with one or both surfaces parallel to the bedding plane covered with vitrain (fig. 1d). Vitrain is more resistant to breakage than fusain, but is much weaker than clarain. It is the secondary cause of breakage in mining and preparation. Clarain, on the other hand, is closely knit together and stands up well under mechanical handling. When durain is present, it is the toughest and most resistant component. It is of little importance quantitatively, as clarain, vitrain, and fusain probably make up over 99 per cent of the combustible parts of Illinois coals.

These breakage characteristics have a great deal to do with the kind of coal that goes into the prepared sizes. Both vitrain and clarain can be found in the lump, and most of the surfaces will have a thin layer of fusain on them where the lumps have split along fusain layers. Most of the fusain has broken off, however, and will be found in the screenings, or if the coal is dedusted it will be found in the dust.

The egg (3 by 2 inches) may have some of the smaller vitrain bands, but for the most part is clarain. The No. 2 nut (2 by 1¼ inches) is still

* This paper has been published since the Conference in the Mining Congress Journal, vol. 23, no. 12, pp. 18-19, 1937.

richer in clarain. In most coals the No. 3 nut (1¼ by ¾ inches) is 8 to 10 per cent higher in vitrain than the coal bed from which it was mined.

Vitrain continues to concentrate below 48-mesh in most instances until the 100- or 200-mesh size is reached. Below this the fusain is ordinarily highly concentrated.

Washing may play a considerable part in separating the ingredients. In the minus 1¼-inch screenings from one mine, 58.9 per cent of the coal floats at 1.30 sp. gr. The coal floating is 58.2 per cent vitrain, 40.0 per cent clarain, 1.1 per cent fusain, and 0.7 per cent middling refuse. The average vitrain content of the coal bed is only about 20 per cent. This vitrain content is so highly concentrated in the fraction floating at 1.30 sp. gr. that there is, as previously indicated, a diminution of vitrain and an increase of clarain in the nut and larger sizes.

The Coal Division of the State Geological Survey recently made a microscopic analysis of a washed ⅜-inch by 48-mesh coal from an Illinois mine which showed the following composition in comparison to the coal in the seam:

	Washed ⅜-inch to 48-mesh (per cent)	Coal Bed (per cent)
Vitrain	40.8	19.0
Clarain	51.9	60.9
Fusain	2.6	4.5
Refuse	4.7	6.6

The foregoing summary of the effect of sizing and washing and the chemical characteristics and distribution of the banded ingredients give a generalized view of the information collected for the purpose of conducting studies of how these different sizes and, consequently different mixtures of ingredients burn.

To understand and make use of these differences is the problem which now confronts us. Differences of several hundred degrees in the fusion points of the ash from vitrain and clarain have been reported.

There is a wide difference in ease with which the bands grind. Durain is difficult to grind, clarain is less difficult, vitrain grinds easily, and fusain offers little resistance. These are important considerations where the coal is powdered before firing and the cost of grinding must be considered.

Much of the difficulty of uneven burning in the stoker fuel bed may be attributed to the high-swelling nature of the vitrain which our studies have shown to be concentrated in the stoker sizes. Crushing egg and large nut sizes, which are high in relatively free burning clarain, and mixing them with the normal stoker sizes or marketing the product as a special stoker fuel, may be desirable for some mines.

These characteristics are strikingly brought out in several hundred feet of colored moving picture film which the Survey has made of the combustion of the different coal ingredients from the same mine. In the high vitrain fuel marked coke tree development was obtained accompanied by "blow holes" in the fuel bed. A very even fuel bed developed in the clarain.

Other fuel problems may arise because of the physical behavior of the bands which make up the coal. Sometimes a regional study of the coal beds may suggest changes in screening or washing procedure which will alter the composition of a particular coal.

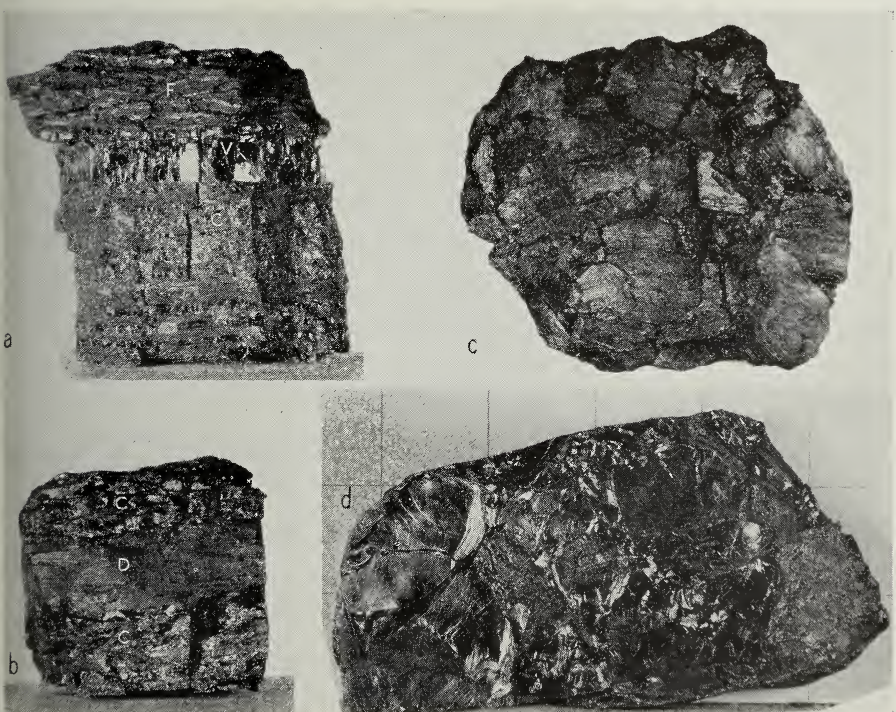

FIGURE 1.—Coals showing fusain, vitrain, clarain, and durain and common causes of breakage.

a. Block of No. 6 coal composed of fusain *(F)*, vitrain *(V)*, and clarain *(C)*; b. Lump of No. 6 coal containing clarain *(C)*, and durain *(D)*; c. Fusain as it appears on the surface of a block. This is a common cause of breakage; d. Block turned on edge to show break in vitrain (2-inch grid).

AIMS OF THE BITUMINOUS COAL ACT OF 1937

By

Hon. Walter H. Maloney

Commissioner, National Bituminous Coal Commission, Washington, D. C.

Mr. President, Ladies and Gentlemen:

It is an honor and is certainly a tribute to the National Bituminous Coal Commission that you requested a member of the Commission to appear here on this occasion. I am pleased to bring to you the sincere good wishes of every member of the Bituminous Coal Commission and to say that the Commission is very happy to accept your gracious invitation.

You are, doubtless, acquainted with most of the problems that have for years beset the bituminous coal industry and, likely, know in a general way the effort projected by the Government in displacing chaos and destruction with a better business arrangement offering security to all concerned in the industry. It is my opinion, however, that too few of the people of this country realize the necessity for what is being done by the Government, and the great import of this step.

I can assure you the National Bituminous Coal Commission, charged with the duty of administering this law, welcomes any opportunity to discuss with you the problems that must be met, understood and overcome. It is our hope that as the Nation becomes acquainted with the involved conditions in the coal industry there will arise a clearer understanding among you, those of the industry, and those concerned with legislation, which will result in continued betterment and ultimate solution of the troubles of this long-time ailment.

Coal is the business of all the people of these United States. That may impress you as rather an extravagant statement, but impartial surveys show that directly or indirectly the production and merchandising of bituminous coal affects the welfare, comfort and happiness of all but a very few of our population. It is definitely a matter of great and grave import to the Government as it serves the people.

Another vital interest of the Government is apparent when we contemplate the vast amount of energy furnished by bituminous coal in turning the wheels of industry and commerce in these United States.

I observe from the program I am asked to discuss the "Aims of the Bituminous Coal Act of 1937." This is a happy privilege. We must remember at the outset that the objective of the Bituminous Coal Act of 1937, and the task of the National Bituminous Coal Commission, is not merely one of making it possible for the operators and others engaged in the industry to make a profit. That is *one* of our primary objectives. But we have also to consider the economic and physical welfare of more than 600,000 miners who are employed in this industry; we must consider the welfare and protection of the consumer, and all the great industries that "King Coal" serves; and we *must* provide for the conservation of this greatest of all natural resources while conservation is still within the realm of a possibility.

It is necessary that we discuss briefly something of the recent history of the bituminous coal industry—by recent I mean approximately the last 20 or 25 years. I might go back of that period and demonstrate, that for many years prior thereto the conditions which exist today, were in the making. The history of the coal industry is one of bad management, waste and bad merchandising. Not even the example of modern progress in other industries served to eliminate these conditions. The Bituminous Coal Act of 1937 is not the creation of a recent impulse. It is the product of years of impartial and, if you please, nonpartisan study—and, I regret to say, of bitter experience. The facts and studies which led your Government to the adoption of this Act were not gathered within the last two or three years. Since the reconstruction period, following the World War, the Government has been deeply concerned about the situation which has existed within the industry, and throughout that period it has been actively considering a remedy. The libraries in Washington and elsewhere are filled with countless volumes of reports and recommendations and statistics about this problem. Heretofore, efforts toward a solution have been confined primarily to inquiry and academic discussion. Now we are about to translate research and discussion into terms of action, to replace volumes upon volumes of printed words with definite accomplishments.

The matter of conserving the sources of energy is not something that can be left to future generations. Too long have we postponed such action, and as a result millions of tons of coal already have been lost irretrievably. It may seem strange to the layman, as we witness the great competition coal now encounters from oil and gas, to learn that eventually coal must again take the place of these sources of energy. Our reserves of oil and gas are extremely limited, and the power load that is now being carried by these fuels will have to be produced from coal in a comparatively short time, thus increasing future demands upon our reserves. We once had a comforting notion that our reserves of coal were almost unlimited, with a sufficient quantity in the ground to carry us through probably 5,000 years. More accurate analyses show, however, that the best expectancy is about 300 years, but in thinking of such a period of time you must have in mind, and what is more important. that the probable life of our fields of high grade coal is nearer 100 years.

But even these arresting figures do not tell the story of bituminous coal. The picture we must fix in our minds is not one of danger of absolute exhaustion in the future, but rather an early and impending increase in the cost of coal to industry and the domestic consumer, if depletion of the rich and accessible deposits continues at the present rate. This can be prevented.

Despite an original magnificent endowment, depletion is further advanced than even mining men generally realize. It is true, that there are stupendous reserves of low grade bituminous coals, but shocking indeed is the knowledge we now have that in many of the high grade seams depletion is far advanced. Already, the great Moshannon bed is but a memory, only a few acres of virgin coal remain in the famous big vein of Georges Creek, and the life of the Pocahontas and New River coals is good for not more than two or three generations, and that of the Pittsburgh seam in Pennsylvania is of somewhat uncertain duration. Competent authority tells us, that the highest grade gas and metallurgical coals are 11 per cent exhausted in West Virginia and Virginia. Ponder well the fact, that the Pittsburgh bed in Pennsylvania and the southern low and high volatile metallurgical coals are the foundation of our great American steel industry. Thus the cold truth of mathematics shows unnecessary depletion of these great beds will handicap not only the steel industry, but every other industry that depends upon steel.

Why do these conditions exist? What is the great underlying cause for the deplorable waste of our greatest natural resource? I shall not answer these questions with facts obtained by the National Bituminous Coal Commission. I will turn instead, to the reports of investigators and boards, which preceded our Commission by many years; for instance, the report of the National Coal Commission, that was appointed by President Harding in 1923, and which was headed by John Hays Hammond, one of the greatest engineers of our time. I could refer you also to the field investigation which was conducted by the Bureau of Mines at the request of the Hammond Commission, and to government, state and industry publications dating back many years. The unanimous opinion of all has been, that we have literally wasted a treasure house of energy, because we have permitted mismanagement, bad management and no management, where orderly and profitable business methods should have existed. With spendthrift abandon our resources have been wasted to an extent, which now brings us face to face with the truth, that symptoms of advanced age in our coal supply are becoming apparent.

Consider these figures. For the last 10 years the production of bituminous coal in the United States averaged 483 million tons annually, and in each of those same 10 years, approximately 250 million tons were lost, much of it lost beyond hope of recovery. According to accurate field studies in 1923, conducted by the Bureau of Mines and the Hammond Commission, the average waste has been more than 35 per cent, of which 15 per cent was unavoidable, but 20 per cent was sheer waste. What does this mean in terms of tons? It means that every year 150 million tons of coal have been left in the ground and are lost forever. Mind you, 150 million tons per year. Measured by the yardstick of energy, that is equivalent to double the production of natural gas in the United States. And even more deplorable, conditions have not grown better, they have become worse.

Howard N. Eavenson, past President of the American Institute of Mining and Metallurgical Engineers, testifying in the Appalachian Coal case in 1932, said:

> "The depressed condition in the coal business has had a great deal of effect on the waste in the mining of coal. Since the depressed condition of the last seven or eight years, a good many mines have found that it is very much cheaper for them to lose a very considerable proportion of the coal in the ground than it is to try to mine it. In other words, instead of recovering 85 per cent or more, a number of them have gone to a practice where they will not get ultimately more than from 60 to 65 per cent, because the ultimate result is cheaper than if they tried to mine the greater amount of coal. I think I could make the broad assertion that there is not a single bituminous mine in the country today that is not mining the very best coal that it has, and the cheapest, and is allowing portions of the mine to get into shape where a lot of the coal will never be recovered, because they cannot afford, at present prices to mine it."

Again, according to Newell G. Alford, from 1923 to 1932, no less than 4,802 bituminous coal mines were shut down or abandoned. Exhaustion accounted for but a small percentage of this mortality. The great majority of these old pits are not likely to be reopened. The quantity of coal lost through collapse of roof, crushing of pillars and stumps, or through permanent isolation of odd acreages must certainly run into hundreds of millions of tons. If such a thing happened in a country like Belgium, or any one of several foreign countries, such a loss would be considered a national calamity; but in our own United States we delude ourselves into false beliefs about the extent of our resources, and passively approve what is going on. This is a fallacy that no longer can be ignored.

In the presence of uncontrolled and ruinous competition, coal has for years been sold far below the cost of production and at prices cheaper than the dirt under our feet. In effect, the coal industry has been dying of economic starvation in a poorhouse of its own making. The waste that has grown from year to year is not the fault of the individual operator who has little or no choice under existing competitive conditions. The operator has neither the economic incentive, nor the financial means, to prevent waste, while the bituminous coal industry continues to exist amid surroundings of constant warfare and stark poverty. Obviously, the first step is to take this industry out of such surroundings and place it on a basis of economic stability and respectability—and that is exactly what your Government proposes to do under the Bituminous Coal Act of 1937. But the National Bituminous Coal Commission has other duties to perform along with that of putting the industry on a business basis. We make it possible for the producer to mine coal profitably without unnecessary waste, we also have the immediate responsibility of protecting the consumer, and in that duty we shall not fail. Briefly, our purposes may be summed up in four points:

1. Stabilization of the industry to preserve capital,

2. The maintenance of reasonable wage standards and stable employment through the establishment of normal economic conditions within the industry,

3. Conservation of the nation's coal resources, and

4. Protection of the consumer against unreasonable prices, not only in the immediate future, but in the more distant future through the conservation of our coal supplies.

Now I want to talk to you for just a moment about this question of labor. As I have said before, approximately 600,000 men earn their living by mining coal, and considering their families, nearly 2,000,000 are dependent thereon. The destructive conditions that have existed in the industry have produced not only an economic calamity for the industry itself, but they have resulted in labor conditions of which America cannot be proud, and they have taken a terrific toll of human life. In the 24-year period from 1910 to 1935, no less than 42,591 men were killed in the bituminous coal mines of the United States, either by accident or through negligence. This is more than the United States lost in battle during the World War. And for every fatal accident, there were 71 accidents which did not result in death. The United States Government cannot afford to close its eyes to these conditions and say: "Oh, they are merely the hazards of a hazardous industry."

No peacetime industry can afford to be so hazardous; nor need it be. Conscious as we are of the fact that the Bituminous Coal Act of 1937 gives no direct control over mine labor, the National Bituminous Coal Commission nevertheless believes that through the establishment of normal and healthy business conditions in the industry, stabilization of employment, maintenance of reasonable wages, and reduction of the mortality rate, will follow as surely as it has followed prosperity and employment in other lines of industry.

Out of the misery, poverty and failure that rode the back of the coal industry, affecting not only the producers, but the miners and consumers too, there developed an organization of mine labor known as the United Mine Workers of America. All of us know the conflict that inevitably developed between the union and the producers. With the exception of one union here in the State of Illinois, the United Mine Workers constitute the sole labor organization in the entire industry. And it is worthy of note, and only fair to say, that under the effective, useful and dominant leadership of that organization and its leader, the industry has obtained the only relief it has known to this date.

That the mine workers have faith in the ability of the present law to remedy conditions within the industry, is shown by the fact that at the hearings preceding the adoption of the Bituminous Coal Act of 1937, Mr. John L. Lewis, President of the United Mine Workers of America, frankly stated that if it were not for the passage of that law, his organization would have to adopt the only weapon it had at hand for the common defense of its members. Thus the law is serving also to preserve peace between workers and producer, while the Commission carries forward the work of establishing order and prosperity on a basis of permanency.

So now we come to the law enacted by Congress to establish order in the bituminous coal industry. This law is not an attempt to inflict unreasonable or unnecessary regulations upon those who produce coal. On nineteen different occasions Congress has considered the problems of the industry. It has had the benefit of years of experience and help from impartial groups. That the time for the translation of academic discussion into affirmative action has long since passed, is shown by the report of the Hammond Commission, which was submitted in 1923 and said in words that no one can misunderstand:

> "The *Government* must go beyond continuous fact finding and publicity, important and elementary as these functions are. * * * *
>
> "* * * * The Government can act only through administrative agencies and it is clear, that if anything is to be done at all commensurate with the gravity of the problem, an effective agency, with sufficient funds, experience and power at its disposal, must be charged with the direct responsibility for such regulation and supervision as is necessary. Honest and efficient coal operators and dealers have nothing to fear from this. On the contrary, they have reason to welcome it."

And now you have the law, 14 years after it was first recommended by the Hammond Commission. It is not an arbitrary statute that takes away the rights of anyone. It merely preserves the rights of all. Sound in concept, and thoroughly American in administration, it provides every check to protect the rights of the industry. It establishes the means whereby the industry, with the assistance of the National Bituminous Coal Commission, may set its own house in order; it does not centralize administration in one place, but leaves much of it out in the districts where coal is produced; and it specifically reserves to every producer his right to a fair, full and judicial hearing before the courts of the United States if other means fail. It is not the product of Government desire, rather it is the result of a demand from within the industry itself. It is a gift from the Government to the coal industry.

The Commission is conscious of the fact that some may regard it as a step toward tossing business and industry generally into the power of a governmental bureaucracy; on the other hand, many coal producers regard it as the beginning of a golden age, wherein profit will be guaranteed without due endeavor; and perhaps some consumers have the notion that it means excessive and unjustified prices. All are wrong. The Act preserves and fortifies sound economic principles. It offers the hope of a reasonable prosperity only to those who have the initiative and energy, plus quality of product, to go out and get the business. And above all, it does not permit the producers of bituminous coal to burden the consumer with unreasonable and unwarranted prices.

The Act provides for the establishment of the National Bituminous Coal Commission, consisting of 7 members, all of whom must be divested of every personal interest in the coal industry. It stipulates that two of the members shall have had experience as miners and two as coal producers, and in clear language the Act says that the administrative force must be a thoroughly impartial body. For the protection of the consumers, it has created a Consumers' Counsel to represent the public and protect the public interest in all matters before the Commission. The Consumers' Counsel is responsible not to the Commission, but directly to Congress to which he reports. While the Commission necessarily is vested with powers, which are essential to the proper administration of the law, the Act provides that no order that is subject to judicial review, and no rule or regulation having the forces and effect of law shall be made until we have given proper public notice of a hearing, afforded all interested parties an opportunity to be heard, and made findings of fact based upon such hearings.

Section 4 of the law provides for a code of fair competition which has been promulgated by the Commission and is required to be filed by all producers of bituminous coal who expect to comply with the provisions of this Act. Those who do not sign this code and comply with the provisions of the Act, will pay the penalties provided for in Section 2 of the Act which is 19½ per cent of the value of any coal produced and sold by such producers.

The coal industry is further protected by the creation of 23 district producer boards, elected by coal producers, and vested with the power to propose classifications of coals, minimum prices, and marketing rules and regulations, subject to the review and approval of the Commission. One half of the members of each board are elected by coal producers voting on a tonnage basis, and the other half by a numerical vote of the producers, while *one* member of each board represents labor. To assist both the Commission and the boards in the proper fulfillment of their duties, provision is made for the establishment of a statistical bureau in each of the 23 districts, into which the entire coal areas of the Nation are divided, to compile information on costs of production, price realizations from the sale of coal, and other vital data. It is worthy of note that this is the first time in the history of the industry such an agency of the Government has been created for the purpose of compiling accurate and complete information on the production and distribution of coal.

The law checkmates any possibility of either the boards or the Commission seizing arbitrary power over the industry, even if such a notion should arise. Every coal producer who becomes a code member under the Act has full power to appeal direct to the Commission for a review of any action taken by one of the district boards, and if the Commission fails to give judicial relief, the appellant may carry his case to the United States Circuit Court of Appeals. Thus every right of the producer, the distributor, and the consumer is protected, strictly according to the fundamental principles of our American system of government.

Probably no section of the law has been more widely discussed than that having to do with the determination of minimum prices. This section of the Act is based upon the sound business principle that coal is a commodity which shall not be sold below the cost of production, and with that policy I believe no one will take issue. Congress reviewed the principle of restricting each individual producer to sales at or above his individual production cost, but obviously, if this had been written into the law, a premium would have been placed upon efforts to reduce production costs regardless of the method employed. That policy had been one of the principal causes of ruinous price-cutting and wage reductions. So Congress divided the producing fields of the entire Nation into 10 minimum price areas, each possessing common production and distribution characteristics and problems. The law provides, therefore, that minimum prices shall be based upon the weighted average of the total production cost, per net ton, in each of the price areas. Thus, we have found a broad and fair highway to the elimination of cutthroat competition, which has wasted our coal reserves, resulted in merciless slashing of wage scales, and created the unparalleled expedient of selling a commodity below the cost of production.

For many years schedules of freight rates have to a large extent determined the availability of coal markets, and very generally transportation costs have exceeded the selling price at the mine. Congress, taking due cognizance of these facts, has authorized the National Bituminous Coal Commission to make complaints to the Interstate Commerce Commission with respect to rates, charges, tariffs and practices relating to the transportation of coal and the prosecution thereof. The district boards and the Commission are also required to apply the principle of forbidding sales, at less than cost of production, in a manner to meet the changing conditions of the industry and the competition of other sources of energy.

But in no sense, does the Bituminous Coal Act of 1937 permit governmental control of production. Subject to the maintenance of minimum prices and proper marketing rules and regulations, as established by the Commission, every producer may mine as many tons of coal as he is able to distribute to his own markets. Those producers who show higher degrees of efficiency, whose coal is more readily accepted by consumers, and who enjoy the benefits of natural and geographical advantages, are not to be deprived of those advantages, but are to retain them for themselves by way of increased rates, safeguarded at the same time against unprincipled and unsound business practices of competitors who may measure success only by the yardstick of tonnage, and who seek to hold their positions in the markets by indiscriminate price-cutting.

The erroneous idea that this Commission fixes the price of coal, has too often been conveyed to the public through the conclusions of critics of this law and those who read it solely for the purpose of criticizing.

I have said before that the consumer would be protected against excessive prices, and in this connection Congress has vested authority in the Commission, in times of emergency, to establish maximum prices which may be charged by coal producers.

The Bituminous Coal Act of 1937 was drafted, not merely to provide for immediate needs but to build a foundation for the more distant future. Despite the failure of the industry to regulate itself in the past, Congress has left the door open for such voluntary action. To this end, the Act gives clear recognition to marketing agencies as a lawful method of cooperative action in the coal industry, and Section 12 specifically provides that marketing agencies may, as between members and as between agencies, provide for cooperative marketing of coal upon compliance with certain conditions which are prescribed in the Act. Thus such marketing or cooperative agencies among coal producers may carry on their business without fear of prosecution, and again for the first time, we have a law permitting members of a great industry to join in such efforts under the protecting supervision of the Government.

The law also empowers the Commission to conduct research and studies into the many problems incidental to the production, distribution and consumption of coal, and under this provision there can be created and carried out a broad program which will serve to guide the industry along the road of progress in the future, enabling it better to meet the competition of modern developments.

Obviously, the elimination of unfair trade practices is essential to the stabilization of the coal industry. Congress has provided for this. Specifically declared to be unfair trade practices are such activities as the misrepresentation of the quality of coals; allowance of secret rebates or price concessions; any attempt to purchase business by gifts or bribes; unauthorized use of trade-marks or trade names already adopted by competing operators; inducing breaches of contracts between coal consumers and competing producers; and shipment from the mine of unordered coal, a trade practice which in the past years has demoralized coal markets. Similarly the law classifies prepayment of freight charges with intent to grant a discriminatory credit allowance; also any attempt to purchase information concerning competitors' business; and, the employment or appointment of any person or sales agent at a compensation obviously disproportionate to the ordinary value of the services rendered, and whose employment or appointment is made with the primary intention of securing preference with a purchaser of coal.

These, gentlemen, are the primary provisions of the coal law. Time does not permit me to go into minute details, and in explaining those I have here presented, I have not attempted to confine myself to legal phraseology or official interpretation. Instead, I have sought only to give you a briefly summarized picture of the Act that has been adopted to raise the bituminous coal industry from the depths of poverty, destructive practices, and low labor standards, to the position of an economically sound and financially prosperous American business and industry.

My friends, politically and economically, we are a favored nation. We enjoy the fruits of peace and progress; we have been spared the burden of heavy armaments; and we look to the future with confidence and security. These things are true because we were endowed at the beginning with vast natural resources, which make us largely a sustaining nation. We shall enjoy these benefits so long as we preserve the gifts of Providence. Ours is not the task of building only for today, for if we do, then our structure will rest upon a foundation of quicksand. Ours is the duty of building both for the present and the future. To the National Bituminous Coal Commission, under the law as it has been adopted, has been entrusted the duty of conserving our greatest natural resource and building up one of our greatest industries. Beyond that we have no aims and no purposes. To that end and that purpose our whole effort is dedicated.

In conclusion, may I ask the coal industry—What degree of confidence have you in your Government? Is there any reason why you should doubt its sincerity in this effort to cure an ailment of long standing? May I remind you, the railroads of the Nation trusted the Government when the Interstate Commerce Act was adopted, and who would now be without it? We believe you should have faith in your Government; it has always served its people well; it cannot fail in this test that will lead the way to a new confidence in government and people, as well as an improved industrial safeguard in times as perilous as those in which we now live.

SMOKE PREVENTION MEASURES AND ILLINOIS COAL*

By

Osborn Monnett

Consulting Engineer, Commercial Testing and Engineering Company, Chicago

The coal deposits of Illinois underlie nearly three-fourths of the State covering an area of approximately 37,500 square miles. In connection with smokeless operation they present a diversified problem when considered from the utilization standpoint. The coals of the State (over 30 per cent) are classed as high volatile in rank. Ash and sulfur content vary considerably in the different fields as does the fusion point of ash. For this reason the design of furnaces and boiler settings for any particular location should take into consideration the field from which the major part of the fuel is to come.

Illinois coal is sold in the industrial, railroad and domestic market and it is in this order that discussion of the problem will be attempted. Perhaps it would first be well to take up briefly the standards by which smoke is judged and the degree of smokelessness required by ordinances. Most smoke ordinances are based on the Ringelmann chart, which divides the degree of density into five divisions: (1) 20 per cent dense; (2) 40 per cent; (3) 60 per cent; (4) 80 per cent; and (5) 100 per cent. The degree of density prohibited by most smoke ordinances is No. 3; smoke that is 60 per cent dense or "smoke that cannot be seen through" is allowed for six minutes in any one hour when the fires are being cleaned. On this basis a plant making this much smoke per hour, would be running 6 per cent density. In areas where smoke abatement work has been going on for years there is a tendency, by special rulings, to cut down the amount of No. 3 smoke and even to object strenuously to No. 1 and 2 smoke, if persisted in for long periods. For instance, if a plant made No. 1 smoke continuously, it will have a smoke density of 20 per cent, which is three times the density allowed by the six-minute clause.

With the above considerations in mind, it can be seen that to burn Illinois coal in a satisfactory manner, the smoke density should be kept well under 20 per cent or No. 1 smoke. As a matter of fact, hand-fired H.R.T.

* This paper has been published since the Conference in Coal-Heat, vol. 32, no. 4, p. 52, 1937.

settings with plain grates have been and are being operated with Illinois coal inside of 2 per cent smoke density. It has been the practice in most smoke abatement campaigns to attack the industrial smoke first, largely because more rapid and spectacular progress can be made and because of the theory that the little fellow should not be bothered, while the big fellow was permitted to operate unrestrained. So it has come about that industrial boiler settings have been the object of careful study for many years. In fact, many communities limit their activities to industrial smoke and let the little fellow go.

Perhaps in no other state has there been made so intensive a study of the various industrial power plant boiler settings, as in Illinois. The notable work of Prof. Breckinridge and his associates at the University and the work done here in later years, as well as the standards developed by the Department of Smoke Inspection, City of Chicago should be mentioned. In the main the coals of this State together with those of other states, east and west, can be classed as free burning, medium- to high-ash, according to the fields from which they come. This type of coal has always been eminently suited to the chain grate type of furnace which has wide use in industrial work in Illinois. It still holds its own and is used in all parts of the State with coals from any of the fields, whatever the quality. Natural draft, front feed, side feed and gravity feed stokers, semi-stokers and furnaces are satisfactorily using Illinois coal of varying ash content from widely separated fields. These furnaces are generally found in units of 75 to 350 h. p. and fit into an important field in which industrial usage requires units with moderate rates of combustion.

The underfeed stoker is also in use in the Illinois industrial field. With the high boiler ratings now obtained, the forced draft of the underfeed with its correspondingly higher rates of combustion, naturally follow. The underfeed type handles the better grades of Illinois coal very well up to the limit of the fusibility of the ash. The low grade high ash coals of the State are not so well adapted to the underfeed. In underfeed installations careful consideration should be given to the required rating of the unit, the combustion rate, the ash content and the fusion temperature of the ash of the coal to be used.

Hand-fired units above 50 h. p. with plain grates may be considered as obsolete. While it is possible to operate such units with a very satisfactory smoke density, it requires great skill and careful supervision, and units of this size are not now permitted in congested communities where smoke ordinances are enforced.

Development in the last few years of the overfeed type of stoker has provided another means for utilizing the very lowest quality of coals produced in the State. With this type the zone of high temperature is above the grate, consequently the ash content and the fusibility of the ash are not such serious factors. This type of stoker utilizes the small sizes which have been largely a waste product. This should prove to be a benefit to not only industrial users, but to the producers of Illinois coal. From the smoke inspector's standpoint there is one consideration, however, which must be noted in connection with overfeed stokers. Burning coal partly in suspension, with forced draft involves the production of fly ash. In old boiler installations with inadequate settling chambers, this is still a problem. Better results can be expected from newly designed settings which provide dust-settling facilities in the gas passages of the boiler.

Smoke from railroad sources, if unrestricted, may form a large percentage of the total smoke of any community. It is possible, with the co-operation of the railroads, to reduce this to a very small figure in comparision to that produced by other classes of smokers. Standardized devices on locomotives, together with constant training of firemen and close supervision by road foremen have made it possible to operate in most classes of railroad service with less than No. 1 smoke. The principal problem at the present time is with intermittent switching service and in round house operation.

In Scotch marine and other special types of boilers, the overfeed principal gives promise of furnishing a satisfactory solution of the problem. Attention is becoming more and more centered on smoke from heating plants. As the industrial boiler settings are modernized it is becoming apparent that heating smoke is a problem that has not yet had the attention it deserves. This class of smoke constitutes as much as 70 per cent of all the smoke of some cities. In Illinois there has been a tremendous increase in the number of small stoker installations on heating plants in the last few years. The small underfeed stoker at the present time dominates this field. The rate of combustion is low and Illinois operators are producing stoker sizes of coal specially for this service. This permits Illinois coal to be used in heating plants from residence size up and comply with all regulations regarding smoke. The small residence stoker is gaining favor daily and is making a good record in economy and smokelessness as compared to other fuels. It is reasonable to expect a large application of these stokers among householders.

Inevitably there remains in every community the miscellaneous collection of stoves or small furnaces which for one reason or another will never be equipped mechanically to burn soft coal without smoke. It is this last class of smoker which is giving the most trouble. For years the U. S. Bureau of Mines and others have recommended methods for firing stoves and furnaces with high volatile coal of which the alternate method of firing has been the most successful. It is possible for a careful person, firing by this method, to operate easily within the limits of No. 1 smoke. With the longer firing period, less soot and greater economy result. These methods have been taught to householders in educational campaigns from time to time in the hope that some progress could be made. In spite of all efforts the results have been only partially successful. Owing to the large number of persons involved and the inherent carelessness of the individual, the tendency, even after instruction, is to lapse back to the old methods.

The only 100 per cent solution to the smoke problems is an absolutely smokeless, fool-proof fuel, supplied at a figure which will make it possible for every one, even the poorest of families, to use. This, however, is not beyond the realm of possibility. A smokeless fuel from small sizes of Illinois coal is being produced with the Curran-Knowles process. Several hundred thousand tons per year of this fuel are now being supplied to the heating and domestic trade. Research is active in this field and other processes are being investigated. At Urbana the Piersol briquetting process has reached a gratifying stage of development.

On the whole there need be no fear but that Illinois coal can and will in the future be burned smokelessly in all classes of equipment. As technical progress advances the Coal Measures of Illinois, which are such an important source of revenue for the State, will continue to hold their own.

DEVELOPMENT OF A HAND-FIRED DEVICE FOR BURNING BITUMINOUS COAL SMOKELESSLY IN THE DOMESTIC FIELD

By

Julian R. Fellows

Associate Professor, Department of Mining Engineering, University of Illinois

In connection with Mr. Monnett's subject "Smoke Prevention," I thought perhaps you might be interested in the Down Draft Conversion Burner on which I have been spending what time I could spare from my regular duties as Associate in Mechanical Engineering at the University of Illinois.

High volatile bituminous coal can be burned as efficiently and as smokelessly with the down draft principle, properly applied, as with the underfeed principle; in effect, the two principles are the same. In either case, the coal gases are heated to a temperature higher than the ignition temperature by the incandescent carbon or coke through which they pass. If, following this heating process, the gases are mixed with the correct amount of oxygen or air, they will burn without the production of any smoke.

The advantage in the down draft principle is that the natural draft of the chimney is sufficient to pull the gases through the incandescent coals and deliver the air to the proper places for admixture with the gases. This principle can, therefore, be used without any mechanical equipment whatever.

About two years ago I conceived the idea of a down draft conversion burner which could be applied to any conventional updraft domestic boiler, furnace, or stove. The burner which is installed through the firing door without making any changes whatever in the original plant, is illustrated in principle by figure 2. Two vertical sections of a conventional warm air furnace are shown. Both sections are taken through the center of the furnace and show the down draft conversion burner in a freshly charged condition.

The burner consists simply of an inverted double-walled box which is suspended from the firing neck of the furnace with the open side down. The box or charging housing may be used with or without the coals spreader shown in the illustration. The coals spreader, which is also suspended from the firing neck of the furnace, is helpful in maintaining the coals from the previous charge at the necessary level for smokeless operation. Practically the same effect can be attained with a very deep ash layer or by lowering the parts of the walls of the box which extend into the combustion chamber of the furnace.

The operation of the burner consists simply in poking the coals down to a level about one inch above the lower edge of the walls and filling the box with coal. When a charge of green coal has been placed it immediately begins to coke at the points where it is in contact with the hot coals from the previous charge. The gas produced by the coking process is drawn through the incandescent coals directly below the coking region and heated to a very high temperature. The air spaces between the two walls of the box are designed to deliver the correct amount of air in such a way that it positively mixes with the highly preheated gases; thus fulfilling all of the requirements for their complete and smokless combustion.

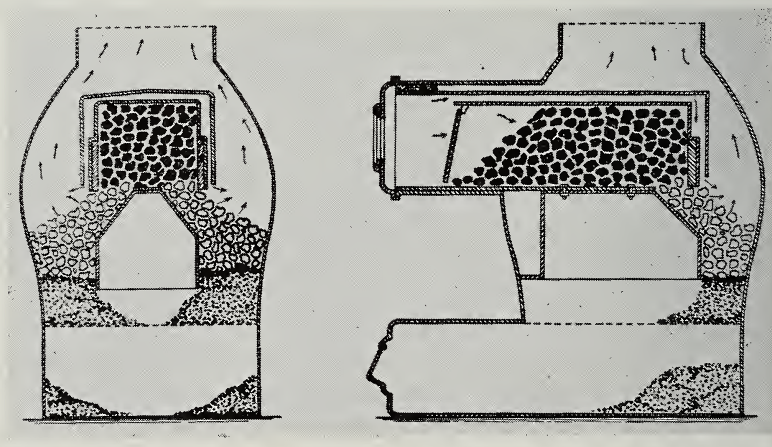

FIGURE 2.—Sections of a warm-air furnace showing downdraft burner in place.

Since the charge of green coal is not heated by the flames as in the conventional way of burning coal, the coking process and the amount of heat delivered can be controlled at will regardless of the amount of green coal in the furnace.

The furnace controls are used exactly as before. The chain running to the ash pit draft door is changed to a small draft door on the main door of the burner. When the fire is turned "on," air is admitted through this small door into the inner compartment of the charging housing. This air passes through the green coal and the oxygen unites with the glowing coals just below, producing heat at this point which accelerates the coking process and the evolution of gas. When the fire is turned "off" this small draft door is closed, cutting off nearly all of the air passing through the fuel bed so that the evolution of gas is decreased to correspond with the decreased amount of secondary air that is pulled through the passages when the check door in the smoke pipe is open.

The size of the burner, and as a result, the fuel capacity of the burner, is limited by the size of the door opening through which the burner must be placed. Nearly all warm air furnaces will admit a burner of such capacity that the time between firings will not be less than with ordinary hand firing.

Very special heat resisting materials and a very special design to overcome warping are required, but I have worked very diligently on this phase of the problem during the past summer with the financial support of the Binkley Coal Company and the cooperation of their engineer, Mr. Frederick H. Bird, and with the assistance of Professor D. R. Mitchell. I believe that the burner can now be made so that it will stand up for a long period.

If experience with a number of burners in actual service during the coming winter proves the practicability of the design that has been worked out, they will be put on the market. It is hoped that they will make it possible for people with limited incomes to handfire the most economical bituminous coals without producing noticeable smoke.

RECLAMATION OF REFUSE AT ILLINOIS COAL MINES

By

David R. Mitchell

Associate Professor of Mining and Metallurgical Engineering

And

C. M. Smith

Research Assistant Professor of Mining Engineering, University of Illinois

Refuse produced by coal-mining operations may be roughly classed as follows:

1. "Pickings" or the waste product from the hand-picking of coal on picking tables, conveyors or railroad cars. It is characterized by containing a high percentage of good coal and ranges in size from approximately 1 inch to large lumps.
2. Cleaning plant refuse. This is the reject obtained during the operation of a mechical type of cleaning plant. Very little coal is present and in size may be from 6 inches to the finest dust.
3. Waste produced in conjunction with mining operations as underground gob. May be characterized by a high coal content and at some mines by a high sulphur content. Gob will in general range in size from nut to large lumps.

In addition to these three, dust is produced at some mines, incidental to preparing the coal, that is not marketable or brings such a low price that it should be classed as a waste product.

Methods that have been used or proposed for salvaging or using refuse may be enumerated:

1. Refuse that has a fairly high coal content can be used as a fuel under certain conditions for power production at the mine.
2. Marketable coal can be recovered in some instances by crushing and washing pickings and middlings.
3. Sulphur in the form of pyrite may be recovered by hand-picking or washing from some wastes.
4. Waste, free from coal and pyrite, may in some instances make a suitable raw material for rock wool manufacture, brick or other ceramic products.
5. Distillation at the mine of refuse high in coal for recovery of gas and oil by-products.

In 1935 we reported to this conference the first results of an investigation of the utilization of coal mine wastes, which is being conducted by the Engineering Experiment Station of the University of Illinois. Since then the Station has issued Bulletin 285 which deals with the possible economic recovery of coal from such wastes.

The conclusions set forth in that bulletin are that probably two million tons of coal-bearing material are being wasted annually at Illinois mines, and that roughly one third of such material could be profitably recovered as salable coal, adding fully $1,000,000 annually to the gross revenue of the Illinois coal industry.

To date, only picking-table refuse has been sampled and studied, although there are possibilities of recovering usable coal from finer refuse, such as cleaning-plant dusts and sludge. However, we shall focus our attention today on pyrite, a possible by-product of any process designed to recover coal from the coarser wastes, such as pickings.

Just as the coal would come from the lightest end of such waste, the pyrite would come from the heaviest end, its specific gravity being about five. After the coal had been removed from the crushed waste, pyrite could be concentrated by jigging, tabling and possibly by flotation. Such pyrite, if sufficiently pure would be salable to manufacturers of sulphuric acid. In fact, such recoveries and sales are being made in at least four plants in the Midwest, two of which are in Illinois. The usual practice is for coarse pyrite to be picked from the refuse by hand and then cleaned further in a rotary breaker. Small size concentrates may be made by use of a special jig, concentrating table, launder, or froth flotation. There is no universal method of concentrating pyrite from refuse. Each mine presents a problem all its own, the successful solution of which depends on a thorough study of the physical properties of the refuse under consideration.

Specification for pyrite for acid manufacture limit the carbon to 5 per cent maximum, and sulphur to 45 per cent minimum. Size is not important at most acid plants. At others where flash roasting is used the pyrite must be minus 100 mesh. One company has specified 20-mesh or finer. Quotations for pyrite of 45 per cent sulphur have ranged from $3.00 to $4.00 per ton at the point of delivery. Other properties of pyrite such as the presence of arsenic, probably as arseno-pyrite associated with the pyrite, may limit its use even though a concentrate can be made complying with specifications otherwise.

Some notion of the pyrite potentially available from table pickings or from cleaning-plant rejects from Illinois coal may be had from tests which were run on the 1.60-sink fractions of the samples discussed in Bulletin 285.

A portion of the 1.60 sink material from each sample was crushed to minus 60 mesh and float-and-sink tested at a specific gravity of nearly three, acetylene tetrabromide being used as the test liquid. As pyrite and marcasite are the principal minerals having specific gravities more than ordinarily associated with coal, the 2.97 sink fractions should give a product high in pyrite. This was found to be true. Other heavy minerals such as heavy silicates, and iron oxide prevented a concentration of 100 per cent pyrite at this specific gravity.

Twenty samples were tested at 2.97 specific gravity, the average sulphur content of the sink material being about 40 per cent sulphur. Subsequent microscopic examination of this sink fraction showed the pyrite particles to be free from the included heavy minerals most of which are probably lower in specific gravity than the pyrite. It is believed that a 45 per cent or higher sulphur content could be made from the refuse represented by these samples. Whether or not it would pay to build a plant to make such a separation is an economic problem that must be solved at each mine.

Sulphuric acid is our leading industrial acid, 1933 production being estimated at 5,168,000 tons of 50° Bé acid. (1)* This was an increase of about 25 per cent over 1932.

The acid is made from dilute concentrations of gaseous SO_2 by two processes, the older lead-chamber process and the newer contact process. At present each process accounts for about one-half the output, but all recent installations have been contact plants.

Acid plants get their SO_2 from the combustion of sulphur in one or more of three forms: (a) brimstone, (b) pyrite, (c) sulfide ores, principally of zinc, copper or lead. It is estimated that nearly 60 per cent of the 1933 production was from brimstone and 20 per cent from pyrite. Five hundred and fifty thousand tons of pyrite were used, 60 per cent having been imported, principally from Spain.

Several small plants were built in Illinois during the World War years to make a pyrite concentrate. The largest of these was at a stripping mine in the Mission field, near Danville. (2:9-11) It had an annual capacity of 12,000 tons of cleaned pyrite which was marketed to a sulphuric acid manufacturer at about $3.50 per ton. As a by-product, it produced about 7,500 tons of coal annually, valued at $0.80 per ton. Although indications are that it should have been profitable, the plant was reported to be just making expenses. There is no report on where the cleaned pyrite was shipped, nor as to the amount of or who paid the freight. For the year 1915, the U. S. Geological Survey reported that Illinois pyrite producers received about $1.70 per ton for their product. While Professor Young ascribes the discrepancy between this and his reported figure of $3.50 to error, it may represent the freight on the pyrite concentrate from the mine to the acid plant.

The operation of this plant, coupled with increased demand and price for pyrite during the War led the then local station of the U. S. Bureau of

* Numbers in parentheses refer to citations at end of report.

Mines to inquire into the feasibility of making further use of the pyrite refuse from coal mines. Yancey (3:105-9) examined many specimens which were sent in from Illinois and adjoining states, and reported that 93 per cent of the Illinois samples contained more than 40 per cent sulphur. He stated that it would be feasible to prepare from them a pyrite concentrate containing less than 4 per cent carbon. He estimated that 1,500,000 tons of such concentrates were recoverable annually in the Eastern and Central coal fields.

Following this, Holbrook (4) tested several one-ton lots of hand-picked refuse, which were sent to the Mining Laboratory from the Danville district. These samples contained about 29 per cent sulphur and 40 per cent coal, so they were essentially free of substances other than pyrite and coal.

ECONOMICS OF PYRITE RECOVERY

Holbrook developed a process for treating pyritic refuse which called for a concentration of 1.76 : 1. It provided for the treatment of 50 tons of refuse per day in a jig-and-table plant costing $18,000. His indicated cost of treatment, excluding the cost of the feed material was $1.06 per ton. While his capital cost, $360 per ton-day capacity, seems high, it is so because the plant was to run only eight hours per day. To put it on a 24-hour basis would reduce the cost to $120 per ton-day which is more nearly in line with later estimates (5) for jig-table mills.

Holbrook charges interest and depreciation at 20 per cent per annum which seems high, but this is offset by a $3.00 daily wage, so an estimated concentrating cost of $1.00 per ton of feed seems reasonable. This is exclusive of any cost for the raw refuse to the mill.

As to the returns to be expected from the operation of such a mill, the mean annual value of the pyrite produced in the United States (6:680) declined from 10.4 cents per long-ton unit in 1929 to 7.62 cents per long-ton unit in 1932. The price that has been mentioned recently is $3.00 per ton for 40 per cent sulphur content, or 7.5 cents per unit, delivered at the purchaser's plant. This is to be compared with the quoted price of 18 cents per unit, plus freight from the Gulf Coast for brimstone which is now being used.

Freight charges on pyrite from Illinois mines to acid plants can hardly be expected to average less than $1.00 per ton, which leaves an estimated return of $2.00 per ton of pyrite concentrates, applicable to concentrating costs and profits.

If a concentration ratio as low as 2 : 1 could be achieved this figure would become $1.00 per ton of pyrite refuse, which is the estimated capital and operating cost of the plant. Thus, as a producer of pyrite alone, the plant could break even if its raw materials were supplied to it without charge, but it would have an additional source of income in coal recovered from the pyritic refuse.

Letting the figures stand as they are, it appears that an $18,000 plant treating 50 tons per day, 300 days per year would yield a profit of $0.35 per ton of feed, or an annual profit of $5,250. This is 29 per cent of the investment. While this might be regarded as a satisfactory rate of return it does not allow for any acquisition cost of the feed material. Such a cost must be met, unless the refuse washery is built immediately adjacent to a mine tipple so that the refuse drops automatically into the feed bin of the washery. Were a central concentrating plant built to serve a group of mines, the cost of collecting the refuse and bringing it to the plant would have to be deducted from the estimated profit of 35 cents per ton of feed. It might well amount to one half this figure, thereby reducing the estimated return on the investment to 15 per cent, and making it unattractive.

The foregoing analysis is based on a year of 300 working days, which is not warranted. Illinois coal mines have averaged less than 150 days per year lately, and 200 days may be taken as the maximum permissible estimate. This would increase the capital cost per ton of feed 50 per cent. This cost was 20 per cent of $18,000 on 15,000 tons, or 24 cents per ton. A 50 per cent increase in this item is 12 cents per ton of feed, which, deducted from the estimated maximum profit of 35 cents per ton, leaves 23 cents per ton on the 200-day basis.

In reviewing the estimates on which this postulate is made, the capital costs might be reduced some by building a smaller plant and operating it two or three shifts daily, and the operating cost would probably be less in a larger central plant than in a small plant for an individual mine, like the one predicted. However, the larger plant immediately runs into acquisition costs so capital and operating costs of nearly $1.00 per ton of feed seems to be a fair estimate.

The assumed concentrating ratio of 2 : 1 is dangerously low. As has been stated data at hand indicate that concentrating ratios of 3 : 1 or even 4 : 1 are more probable. This view is strengthened by an examination of the sulphur content of the 1.60 sink fraction in channel or sized samples reported by Mitchell (7:28, 32, 36, 40). Thirteen of these had a sulphur content greater than 20 per cent while 29 had a sulphur content between 20 and 10 per cent. The remaining 25 carried less than 10 per cent sulphur. The last group need not be considered, of course. Of the samples represented in the other two groups, roughly two thirds would require concentration ratios appreciably greater than 2 : 1. Only one-third, those whose sulphur content is greater than 20 per cent, would be amenable to a 2 : 1 concentration. The significance of the concentration ratio becomes evident when it is considered that, under the conditions previously assumed, a 2 : 1 ratio yields one-half ton of pyritic concentrate per ton of feed, netting $1.00 in income to the plant; whereas, a 3 : 1 ratio would yield but one-third ton of concentrate, netting but $0.67. The difference of $0.33 is more than the estimated profit for the entire operation under the foregoing assumptions, operations would be, therefore, limited to pyrite refuse which runs 20 per cent or more in sulphur.

Samples listed in Bulletin 258 with two additional ones from Bulletin 217 whose theoretical yields in 6 x 3-inch refuse met the requirements, are listed below:

SAMPLES MEETING REQUIREMENTS OF THEORETICAL YIELDS

Bulletin No.[a]	Table No.	Kind	Mine	County	Bed	Sulphur refuse (Per cent)	Nearest Acid Plant (Miles[b])
217......	25	5 x 3........	E	....	....	20.9	....
217......	37	6 x 3........	G	....	....	22.2	....
258......	2 G11-2	Channel.....	....	Henry.......	2	22.0	60
258......	2 I14	Channel.....	....	LaSalle......	2	26.1	20
258......	2 AC37	Channel.....	....	Saline.......	2	34.6	120
258......	4 J15	Run of mine.	....	Livingston...	5	20.2	40
258......	4 AN40	Channel.....	....	Gallatin.....	5	31.4	150
258......	4 AE42	Channel.....	....	Saline.......	5	20.6	120
258......	4 AE43	Channel.....	....	Saline.......	5	33.1	120
258......	6 X31	Channel.....	....	Sangamon...	6	22.4	90
258......	6 AA34	Channel.....	....	Christian....	6	21.5	80
258......	6 AD39	Channel.....	....	Gallatin.....	6	26.2	150
258......	8 J2-16	Channel.....	....	Livingston...	7	25.4	40
258......	8 AK53	Channel.....	....	Vermilion...	7	24.0	20

a University of Illinois Engineering Experiment Station.
b Estimated.

It would seem that the place to look for good sources of pyrite refuse is in the neighborhood of any of these samples. Most of these are thought to be within 100 miles of a sulphuric acid plant, which is probably the limit for a $1.00 freight rate.

Differential picking has been suggested as a possible means of selecting the salable pyrite. Since the working time of Illinois mines is so limited it is imperative to keep capital costs at a minimum, and differential picking, being a matter of labor rather than machinery would be a step in that direction. However, since Yancey (3) found many of the handpicked pyritic specimens which were sent to him to contain less than 40 per cent sulphur, and more than 3 or 4 per cent carbon it is unlikely that differential picking alone could develop an adequate volume of salable material to make the venture pay. Nevertheless, Holbrook (4) found that the over-size from a 1½-inch disintegrating trommel was salable, so it might be possible to pick differentially and clean the pickings in such a device, the undersize to go to refuse. This might work out roughly as follows:

One repicker selects 10 tons of pyritic material from 50 tons of refuse per day. On passing through the disintegrating trommel this becomes 7 tons of salable pyrite, bringing in $2 per ton at the plant. The return is thus $14 per day, or $2,800 annually. The annual labor cost would be $1,000. The purchase cost of a 48-inch x 8-foot trommel with drive motor would be about $1,500, which with an additional $1,500 installation and housing cost would make a capital cost of $3,000 on which the annual charges would be $600. With a 10 h.p. motor, the power consumption would cost roughly $40 per year. Thus the total operating cost would be $1,640, giving an estimated net return of $1,160, or not quite 40 per cent on the investment.

While this looks attractive, the underlying assumptions as to daily output of salable material need verification before confidence can be placed in the project.

On the whole, the outlook for marketing pyrite from coal is not promising, but Nicholson* has suggested the possibility of converting the sulphur in the pyrite into sulphuric acid at the mine, thereby eliminating freight charges on the pyrite and securing the profits of acid manufacture to the entrepreneur. He suggests locating the plant near a group of mines in central Illinois which produce 10,000 tons of coal daily, which should yield 400 tons of pyritic refuse. From this could be concentrated 200 tons of pyrite averaging 40 per cent sulphur, at an estimated cost of $200 per day. This is 80 tons of sulphur, which at 60 per cent extraction would yield about 50 tons of sulphur in the form of SO_2 gas. From this in turn could be produced 150 tons of 66° Bé sulphuric acid, which at current quotations of $15 per ton would yield $2,250 daily, or $675,000 annually.

All recent installations of sulphuric acid plants have been of the contact type, the capital cost of which may be estimated (9:190) at $6,000 per ton-day capacity. For the postulated plant this would be $900,000, on which the annual charges at 15 per cent would amount to $135,000. The annual operating cost (9:192) at $4 per ton of acid would be $180,000 which, plus $60,000 concentration cost would bring the total cost to $375,000. This leaves a net annual profit of $300,000, which is 33 per cent of the investment on the basis of a 300-day year. For a 200-day year the income would be 200 x $2,250, or $450,000. The capital costs would be as before, $135,000, and the operating costs would be $160,000, giving a total annual cost of $295,000, leaving an estimated profit of $155,000, which is only 17 per cent on the investment. However, it amounts to $1.94 per ton of feed which sounds like an attractive figure. It is several times the profit per ton indicated from the concentrating plant alone. To this might be added the value of coal recovered in the concentrating plant, or about $0.35 per ton of feed refuse.

Inasmuch as the working time of the plant would be only about one-half of full time, it might be somewhat better to install a lead-chamber plant at from one third to one half the construction costs, but with about twice the operating costs per ton of acid.

* Nicholson, H. P., personal communication to Professor Callen, March 20, 1934.

However, any acid plant so situated would face many grave risks. Perhaps the foremost would be the limited market for sulphuric acid. The price of $15 per ton is apparently an artificial one, since it has been reported at that level, or nearly so, for years. A strong indication that there is a limited market for the acid is that by-product acid plants are operating only at from 10 to 40 per cent capacity (10:35-38), wasting most of their SO_2 to the air. Were there a profitable market for the sulphuric acid represented by this SO_2, they would hardly waste it. Furthermore, there is a definite threat to new acid plant construction in that future legislation will probably increasingly force by-product SO_2 into acid to avoid atmospheric pollution.

Other shadows hang over new acid capacity. The fertilizing industry has been the best user in the past, but the sulphate radical of the acid serves only as an inert carrier in fertilizers, whereas nitrate and phosphate carriers have fertilizing merit in themselves. Recently the trend has been away from sulphuric acid toward these more effective agents. The petroleum refining industry has been the next large user of H_2SO_4, but a similar trend away from the acid is noticeable there. Higher antiknock gasolines require less sulphuric acid treatment, as do the colored gasolines which need not be made water-clear before they are dyed. The result of these and like tendencies is that this industry used less acid in 1933 than in 1932, while producing more gasoline. Furthermore, hydrogenation may lead the petroleum industry to become a producer of H_2SO_4.

In conclusion, we could not advocate new acid plant construction or the construction of a concentrator to ship cleaned pyrite to an existing plant unless one or more of the estimates used in postulating the concentrator were substantially more favorable than those stipulated. These stipulations were:

a. Cost of the plant—$120 per ton per 24 hours, equals $18,000 for a 50-ton plant operating 8 hours per day.
b. Interest, depreciation, taxes, etc.—20 per cent per annum.
c. Feed—free of charge to plant.
d. Concentrating ratio, 2 : 1.
e. Operating cost, $1.00 per ton of feed.
f. Value of pyrite concentrate delivered, $3.00 per ton of concentrate.
g. Freight on pyrite concentrate, $1.00 per ton of concentrate.
h. Value of coal recovered, $0.35 per ton of feed.

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TRENDS IN COAL SELECTION FOR SMALL STOKERS*

By

K. C. Richmond

Editor, Coal Heat, The Stoker Magazine, Chicago

"Dustless treatment," "ease of operation," and "recommendation of the stoker dealer or salesman" stand out in order as major preferences in the selection of coal by household stoker users.

To find out more about the selection of stoker coal, we asked several hundred stoker dealers, retail fuel merchants, stoker manufacturers, stoker engineers, fuel engineers and others what factors govern the selection and purchase of both household and commercial and semi-industrial stoker coal.

Here is what we asked:

> From the stoker user's viewpoint, what factors now govern the selection and purchase of stoker coal for (1) household, (2) commercial or semi-industrial use?
>
> Check these factors numerically—1, 2, etc.—in order of descending importance:
>
> Household
> Commercial
> Semi-industrial
>
> A. Dustless treatment.
> B. High B.t.u. content.
> C. Ease of operation.
> D. Freedom from fines.
> E. Low freight rate.
> F. Minimum non-combustible or low ash content.
> G. Price per ton (low). (Medium cost per season.)
> H. Recommendation of the stoker dealer or salesman.
> I. Recommendation of the coal merchant.
> J. Recommendation of other stoker users.
> K. Special sizing.

Thanks to the enthusiastic cooperation of the major stoker manufacturers, key coal producers, retail coal associations, stoker dealers and others, we secured a consensus of opinion from the men who are selling 80 per cent or more of the stokers and stoker coal in the United States.

The result of their experiences, observation and judgment is shown in the accompanying tabulation, a summary of summaries, each group being accounted for separately. The final order of relative preference is given on the bottom line (see table No. 1).

As will be noticed, this tabulation gives the viewpoint of each group as a group. In other words, it shows the consolidated viewpoint of a number of combustion or fuel engineers as a group, chief engineers of major stoker companies, sales managers of leading stoker manufacturers, members of various retail coal associations and other groups.

* This paper has been published since the Conference in Coal-Heat, vol. 32, no. 4, p. 54, 1937.

PREFERENCES

In order of preferences, dustless treatment stands out first, closely followed by ease of operation. The phrase "ease of operation," of course, takes in considerable territory. Low ash content, clinkering characteristics, coking tendencies, amount of fuel required, frequency and amount of clinkers to be removed, the way the coal burns or holds fire in mild weather—in the early fall or late spring—all come under this heading.

Recommendation of the stoker dealer is a big factor. Several groups marked it first on the list. A few coal operators put this far down the list—which indicates that they are not quite as close to the stoker industry, dealers, salesmen, engineers, manufacturers, as they might well be in view of the rapid growth of the industry and increasing demand for stoker coal.

Low ash content came fourth, recommendation of the coal merchant, fifth, high heat content, sixth. Only one group—the Canton stoker dealers—put high heat content in first place, several groups placed it near the bottom of the list.

SPECIAL SIZING

Despite all the conversation and propaganda about special sizing of stoker coals, it was rated seventh. Technically, this may be erroneous. Practically, special sizing is a concomitant of "ease of operation."

In studying the summary you will notice that only one group put special sizing at the head of the list—the salesmen and representatives of a leading Illinois coal operator. Outstanding fuel engineers put it in third place. A group of fuel engineers in New York put it in second place. Pittsburgh dealers put it in third place. However, the final summary shows special sizing in seventh place in order of preferences.

Price per ton is not much of a factor within certain limitations, of course. By various groups it was ranked 4th, 11th, 10th, 7th, 11th, 5th, etc., "Recommendation of other stoker users" came ninth and "Freedom from fines" tenth. Only a few groups listed "Freedom from fines" near the head of the list, chiefly a group of Cincinnati coal operators and a number of coal merchants in Wisconsin.

FREIGHT RATES

At the bottom of the list came low freight rates. This indicates that the household stoker user is not particularly concerned about the cost of freight—it is the cost of the coal in the bin, the cost of heating per season, freedom from complaints, it is the satisfaction in use and ease of operation that count.

One of Chicago's oldest and best posted fuel engineers, the representative of a company with a large stoker tonnage in the city, told me recently that well over 60 per cent of their stoker users didn't care particularly what the

Table 1—Relative Order of Preferences Governing the Selection of Stoker Coal

GROUPS QUESTIONNAIRED[1]	Household stoker user's viewpoint: Dustless treatment	High B. t. u. content	Ease of operation	Freedom from fines	Low freight rate	Minimum noncombustible or low ash content	Price, per ton (low)	Recommendation of the stoker dealer or salesman	Recommendation of the coal merchant	Recommendation of other stoker users	Special sizing	Viewpoint of commercial stoker users: Dustless treatment	High B. t. u. content	Ease of operation	Freedom from fines	Low freight rate	Minimum noncombustible or low ash content	Price, per ton (low)	Recommendation of the stoker dealer or salesman	Recommendation of the coal merchant	Recommendation of other stoker users	Special sizing
Outstanding fuel engineers	2	8	1	9	11	10	4	5	7	6	3	7	2	3	11	4	6	1	8	9	5	10
Chief stoker engineers	3	6	2	9	10	4	11	1	8	7	5	8	10	6	11	2	7	1	4	5	3	9
Engineers, stoker dealers	2	5	1	8	11	4	10	3	7	6	9	7	6	5	11	2	10	1	3	9	4	8
Mail order personnel	1	2	5	4	11	3	10	6	7	9	8	6	5	4	9	8	7	1	2	6	3	10
Sales managers, stoker manfacturers	1	8	3	7	11	2	9	4	5	6	10	4	7	6	11	9	8	1	2	3	5	10
General managers, stoker manufacturers	4	9	3	7	11	6	10	1	2	5	8	6	8	5	10	10	7	1	2	4	3	9
Members, St. Louis Coal Exchange	2	10	3	6	11	8	9	1	4	7	5	10	5	6	9	11	8	1	2	4	3	7
Cincinnati producers	2	6	5	3	11	4	7	1	9	10	8	10	4	5	11	3	2	1	6	7	8	9
Wisconsin coal dealers	1	9	5	2	10	6	11	3	4	7	8	5	1	9	10	2	4	3	6	8	7	11
Chicago stoker salesmen	2	6	1	9	11	3	10	4	5	7	8	6	2	5	9	11	10	1	3	4	7	8
Illinois coal operator's men	3	2	6	7	11	4	5	8	9	10	1	8	2	7	6	3	5	1	10	9	11	4
Members, Branch office, St. Louis	3	6	4	7	11	10	5	1	2	8	9	6	4	3	10	10	8	5	1	2	7	6
Aurora, Ill., coal dealers	2	6	1	9	10	9	3	4	5	7	8	4	3	6	7	10	11	2	1	5	9	8
Kansas City, Mo., producer	5	9	1	4	8	11	10	2	3	6	7	5	9	1	10	11	4	3	2	7	8	6
Canton, Ohio, stoker dealers	5	1	2	10	11	4	3	6	7	8	9	5	2	4	11	10	3	1	6	8	7	9
Central Michigan stoker dealers	4	7	3	6	10	8	2	1	9	5	9	3	2	7	11	4	10	1	6	9	8	5
Knoxville, Tenn., dealers	1	6	2	7	11	8	10	3	4	9	5	8	3	7	11	4	10	1	5	2	6	9
C. V. Beck	2	5	1	11	10	9	7	3	8	6	4	5	3	4	11	10	9	1	2	7	8	6
Kansas City coal producer	1	10	2	11	9	3	4	8	7	5	6	3	1	2	11	6	4	5	7	10	9	8
Heating engineers, Chicago	5	10	2	6	11	7	1	4	9	3	7	7	1	10	6	4	3	2	5	8	9	11
Fuel engineers, New York City	1	8	5	11	6	3	4	7	9	10	2	6	4	3	10	2	11	1	7	9	8	5
Stoker dealers, Pittsburg, Pa.	4	6	7	9	11	5	10	1	8	2	3	10	9	4	3	8	7	6	1	10	2	11
Stoker salesmen, Chicago	2	5	1	11	10	7	6	3	8	9	4	9	7	1	11	3	4	1	6	8	5	10
Stoker district representatives, Ohio	3	6	4	8	7	11	5	1	2	10	9	8	3	5	10	1	11	2	6	7	4	9
Chicago coal merchants	2	5	1	7	11	4	6	3	9	10	8	8	6	9	10	2	11	1	5	4	3	7
Total score	63	161	71	188	255	153	172	84	157	178	163	164	109	128	242	150	180	45	108	164	152	205
Rank, in order of preferences	1	6	2	10	11	4	8	3	5	9	7	7	3	4	10	5	8	1	2	7	6	9

[1] These groups have been questionnaired so as to get a cross-section of opinion as to the factors governing the selection of stoker coal. The consensus of opinion of each group represents the judgment from anywhere from three or four to several hundred men.

delivered price of stoker coal was—they want the best coal they can get. In some of the foreign sections where there are quite a number of stokers in use, they want the cheapest coal they can get, irrespective of the quantity of ash or the amount of clinkers to be removed.

EASE OF OPERATION

What stands out in this study of household stoker coal is the marked agreement, the demand for proper dustless treatment, for the coal that gives the maximum ease of operation.

Among the commercial or industrial users, on the other hand, the situation is different. Here, the price per ton is the number one factor: Recommendation of the stoker dealer is second; high heat content, third; ease of operation, fourth; low freight rate, fifth; recommendation of other stoker users, sixth; recommendation of the coal merchant and dustless treatment, seventh; low ash content, eighth; special sizing, ninth, and freedom from fines, tenth.

Such are the conclusions of a number of groups selling well over 80 per cent of the stokers and a major percentage of the stoker coal tonnage, based on their experience and observation.

COAL DEALERS

What the coal merchant wants in stoker coal, what factors lead him to handle a particular coal, are shown in table 2. It gives a summary of the impressions, opinions, and preferences of coal merchants in Chicago, St. Louis, Cincinnati, and various key cities throughout the country. In our investigation we had the cooperation of such groups as the Illinois Fuel Merchants' Association, which circularized its membership, the St. Louis Coal Institute, the Extension Service of the University of Wisconsin, members of the Chicago Coal Merchants' Association, the Norfolk & Western, Chesapeake & Ohio railroads, and others.

The final order of preference is given in the right-hand column. As will be noted, the major factors governing the dealer's selection of stoker coal are:

1. Dependability and freedom from complaints.
2. Acceptance of a particular coal in a local community by stoker dealers and manufacturers.
3. Special preparation or sizing.
4. Margin of profits.
5. Prestige or standing of coals from a particular community.
6. Reputation of the coal producer.
7. Present tie-up with a producer or producers.
8. Competitive price and freight rate structure.
9. Special sales helps.
10. Geographic complexes — such as the use of Iowa coals in Iowa, or Ohio coal in Ohio.

Practical business experiences transcend state lines. Economically, there may be certain advantages in trying to use local coal in stokers, but practically, can the stoker dealer or coal merchant jeopardize his relations with customers by recommending a coal the chief virtue of which is that it is produced in the same state, particularly when other coal (in certain geographic areas) can be purchased at approximately the same prices and which actually deliver greater value per fuel dollar?

This is not to be construed in any way as a direct slap at any coal, or any market. All coals can be used. Human nature being what it is, however, just as long as we have any freedom or choice of action, just as long as no dictator forces us to burn this or that coal, just as long as economic barriers are not set which tend to freeze markets, the ultimate consumer will normally burn that fuel in his particular community which works the best.

PRICE FACTOR

Economics is a factor. Price counts. But there is a lot more to this question of household stoker coal than price per ton. The quantity of clinkers to be removed has a lot more to do with whether one's coal is used or not than the price when there isn't a big difference in the delivered price—which happens to be the case in certain communities.

In general, stoker manufacturers and dealers are cost conscious. They want to take advantage of every opportunity to give the home owner the maximum in heating comfort at the lowest possible cost, but not at the price of satisfactory operation.

Just because a coal works well in a stoker in East St. Louis, or because the customer there is well satisfied, doesn't justify the notion that the same coal will appeal equally to the stoker user in Chicago or Milwaukee. Just because certain coals can be used in Indianapolis or Des Moines, doesn't necessarily mean that the household stoker user will find them preferable to a high-grade, low ash eastern coal.

The ultimate consumer is the boss. He wants the best he can get. And the best stoker coal is not necessarily the coal with the finest analyses. Many of us question the chastity of the average coal analysis. Inherent quality alone will not give a particular coal the stoker business.

If one's coal through lack of sizing or insufficient preparation, results in noise from crushing or segregation of sizes, the home owner won't continue to buy it if he can find anything else. Whether or not the new coreless feed screw will revolutionize feed screw design or not, no one knows. Theoretically, the coreless stoker feed screw makes possible the use of considerably larger sizes (even up to three inches), but can such coals be handled without segregation of sizes?

TABLE 2—FACTORS GOVERNING THE SELECTION OF STOKER COAL, BY THE DEALERS

Factor	Order of preference																				Total points	Order of preference
A. Acceptance of a particular coal in the local community by stoker users, stoker dealers or manufacturers	1	2	10	3	3	1	2	1	1	1	5	1	3	1	5	2	8	8	1	1	60	2
B. Dependability and freedom from complaints	3	1	1	2	4	3	1	4	7	...	...	2	2	2	2	1	1	2	2	2	42	1
C. Margin of profits	5	3	5	9	1	2	4	3	6	3	4	3	1	4	6	3	2	3	...	5	72	4
D. Special preparation or sizing	4	7	2	1	5	4	3	4	5	...	...	4	4	7	3	...	3	4	4	4	68	3
E. Geographic "complexes"	10	...	4	10	7	10	9	2	10	...	...	10	9	8	9	...	9	10	...	10	127	10
F. Present tie-up with a producer or producers	9	4	8	8	8	5	7	...	2	...	2	6	...	5	7	...	10	9	...	8	98	7
G. Prestige or standing of coals from a particular district	2	5	7	5	9	9	8	2	4	2	3	5	6	3	1	...	7	5	...	3	86	5
H. Reputation of the coal producer	8	...	3	4	6	8	6	...	8	...	...	7	7	9	4	4	4	6	...	6	90	6
I. Competitive price and freight rate structures	6	6	6	7	2	7	5	6	3	4	1	9	...	6	8	7	5	1	3	9	101	8
J. Special sales helps	7	8	9	6	7	6	10	5	9	...	...	8	8	10	...	8	6	7	...	7	121	9

SEGREGATION OF SIZES

Segregation with screenings is as inevitable as the immutable laws of physics. Segregation occurs even with deliveries of small quantities of stoker coal (under four tons) if there is any marked difference in top and bottom sizes.

The closer the limits are brought together, the less the segregation. D. R. Mitchell and Henry Hebley may well be congratulated for the work they have done in study of segregation. Use of Mitchell's non-segregating chute helps correct the problem in the larger plants. Since building a four-ton bunker in my own basement four years ago, I have had considerable experience with segregation. I know what happens.

TECHNICAL ASPECTS

With many of the technical factors affecting the use, sale and production of stoker coal the ultimate consumer is not concerned. He does not reason why one coal works well, or why another does not. All he wants is heat, hot water or steam with the least effort, at a reasonable price.

Hence, the human equation takes precedence over geology, chemistry, furnace, boiler and stoker design. To ignore John Q. Public, his likes, dislikes, whims, fancies, social concepts, etc., is to play the ostrich. What John Q. gets out of our product is what counts.

Technically, of course, several basic factors affect the use, sale and production of stoker coal. In all their ramifications, these total several thousand. Suffice it to say that heating comfort depends on a lot of things besides coal or a stoker, to-wit:

1. The human equation.
2. Type of housing or building construction.
3. Age, character, condition and operation of the heating system—facilities for heat distribution and control as well as heat generation.
4. Choice or adaptability of the fuel or equipment used.

Putting a bituminous stoker into an old furnace or boiler that was originally designed for anthracite doesn't assure the ultimate in heating satisfaction. The average home is thirty years of age, you will remember. Ninety per cent of the heating equipment in use today is obsolete, when compared with present day standards.

Without an up-to-date heating system, proper building construction, insulation, storm windows, weather stripping, etc., how is the home owner to secure the maximum in heating comfort? If they recognize the innumerable factors affecting satisfactory heating, few men will expect their coal or stoker to perform miracles in any home.

A stoker is but a part of a complete heating system. Fuel is worthless until consumed. What one gets out of a stoker or a coal depends, therefore, on what Bently calls "the equipment and utilization factors."

SIZING

In discussing stoker coal at the Institute on Coal Utilization, at the University of Michigan, recently, Professor R. S. Hawley said:

> From the results of tests it appears that sizes from ⅝-inch down will be more successful in household stokers than will the larger sizes. The best results we have had to date were obtained from coals of ⅝-inch to ¼-inch size.
>
> We have had no difficulty in burning coals with as much as 50 per cent slack. We have observed, however, that when burning slack coal there is a greater tendency for particles of ash to carry up with the gas flow and lodge around the heating surfaces of the boiler or furnace.

Arthur O. Dady, now chief engineer, Stokol, and one of the outstanding engineers in the stoker industry, has commented on the trend toward the use of ¾ by ¼-inch household stoker coal. Dady, in discussing this at a "Short Course on Coal Utilization," at the University of Illinois, said:

> One of the greatest sources of satisfaction is uniformity both in quality and preparation. On stokers of from 100 to 500 lbs. capacity, ¼ by 1¼-inches will satisfy most makes. The percentage of fines below ¼-inch should not, in general, be over 30 per cent.

DIRT AND FINES

Clarence V. Beck declares in his book, "Modern Combustion, Coal Economics and Fuel Fallacies":

> Screenings are not a satisfactory fuel for the householder. They are far too dirty.
>
> The householder who puts in a stoker wants economical heat, freedom from trouble, freedom from dirt. The householder will not stand for the dirt of small screenings. It is almost impossible to wet small screenings so that they will not be dusty. Were it possible to wet small screenings sufficiently to kill the dirt the coal would stick in the hopper and would not feed. This lets out screenings as a domestic fuel for the householder. The fuel for the householder, therefore, must be free of dust and approximately of three-fourths inch maximum top size.

E. D. Benton has pointed out:

> Much has been written regarding the desirability of "fines" in stoker coal. No one questions that evenly mixed fines are desirable in helping reduce smoke and in preventing some coals in being too flashy and burning too fast, but in the great majority of cases, coal is handled several times before it gets into the customers' stoker hoppers. Each time coal is handled segregation occurs. Consequently the stoker feeds all coarse coal at one time and all fines at another.
>
> The air adjustment for one size coal is improper for another. Feeding rates will vary as much as 25 per cent when going from all nut coal to all fines, requiring a further change in air adjustment if any degree of efficiency is to be expected.
>
> The average small user pays little attention to size content or air adjustments, with the result that numerous complaints are received that the coal either will not give sufficient heat or burns too fast. Properly sized quality stoker coal will do more in reducing complaints than any other single item.

A top size that is too large not only interferes with feeding, but is noisy and tends to aggravate segregation difficulties. Too large bottom size causes stokers to smoke back.

It is poor salesmanship to let price interfere with the difference in satisfaction to be received between properly prepared coal for small stokers and coal the sizing of which precludes satisfaction in the majority of cases.

STOKER COAL TROUBLES

J. McClintock, manager, Freeman Stoker Division, Illinois Iron & Bolt Company, Chicago, at a "Short Course in Coal Utilization" at Urbana, says:

At the present time there are more service calls due to delivery of improper fuel than to all other reasons combined. This is the greatest weakness we have in the industry at the present time even with the enormous progress that has been made during the past few years by the operators and retailers in the delivery of better stoker coal.

A thorough analysis by our service department shows that at least 50 per cent of the men's time is spent in what we might call the servicing of coal, a good part of which could be eliminated by a better understanding of the stoker coal business by operators and their representatives as well as the retail coal yard owners and their representatives.

The period is past when the coal industry can get by by having representatives that say "we have the best coal mined." If the representatives, both of the producers and retailers, would make a thorough study of the stoker coal business a large part of the service calls could be eliminated.

COMBUSTION CHARACTERISTICS

Robert M. Pilcher, mechanical inspector, Norfolk & Western Railway Company, Roanoke, Va., in a paper at the University of Michigan, a few months ago, after considerable study and tests of the burning characteristics of Pocahontas coals in stokers, reports:

The size of the coal has some influence upon the feeding characteristics from the hopper to the retort, but within reasonable limits the size has little influence upon the combustion characteristics.

In the majority of household stokers the worm size is such that coal having dimensions in excess of 1½ inches is slow entering the flights and may become so arranged around the entrance to the conveyor tube as to cause the worm to run nearly empty at times.

When such lumps enter the flights a crushing load is placed on the stoker, but because of its friability, the crushing of Pocahontas coal in most cases causes no trouble. In some instances, when coupled with loads already on the worm, it is sufficient to operate the protective devices of the machine.

A coal, none of which exceeds 1¼ inches in size, is best adapted to the average stoker. There are instances when the 1¼-inch size may prove excessive because of the size of the conveyor screw. In such cases the maximum size must be further restricted to obtain satisfactory results.

As to the actual burning of the coal, the size had little effect. Coal containing as high as 80 per cent passing a 16-mesh per square inch screen with a majority of this proportion passing a 64-mesh per square inch screen, gave satisfactory results.

FINES REQUIRE MORE AIR

As the percentage of very fine coal increases, the resistance to air flow becomes greater and it is necessary to increase the air damper opening when burning the fine coals. Also, as the per cent of fine coal in a mixture increases, particularly that portion that will pass a 16-mesh per square inch screen, the coal becomes dustier to handle.

Where slack mixtures are intended for household use, a dustless treatment is desirable, as this will remove any inclination for wetting on the part of the person firing, and thus eliminate opportunity for getting the coal wet enough to arch in the hopper and cause feeding difficulties.

Because of its friability some crushing of Pocahontas coal, regardless of size, takes place in its passage from the hopper to the retort. The larger sizes of coal show a greater degree of crushing than the smaller sizes, so that by the time the coal reaches the burning zone the resultant is about the same whether a nut around 1¼ inches is placed in the hopper or whether a nut and slack mixture is placed in the hopper.

Just as good or slightly better over all efficiencies were obtained when firing mixtures containing high percentages of fines as when firing the sized coals, but where the coal contains large portions of fines, there is some increase in the opportunity for interruption because of improper feeding. This increase, however, is slight and in no way an obstacle in the use of slack coal in any well designed stoker where the designer has considered the use of his machine with a reasonable variety of coals.

FEED WORM CONTROLS COAL SIZE

Frank Hoke, vice president, Holcomb & Hoke Mfg. Company, Indianapolis, at a recent meeting of the Chicago Wholesale Shippers Association, said:

Coal was once a bugbear in the stoker industry. There is one thing that determines the top size of coal which a stoker will feed, the size of the feed worm housing and the size of the screw.

Is 1¼-inch the best size? No, it is not. Throw the coal in the bin and the nut coal rolls to the outside. For a day or two, we throw nothing but nut coal in the hopper. Our air will have to be changed because it takes less air to burn the nut than the fines, which are in the middle of the pile. That is one reason why we should like to have the top and bottom sizes closer together.

Noise is another factor. When we have a 1¼-inch top size, naturally some pieces get caught and make a noise. The more differential between the top and bottom sizes, the greater the segregation when a car of coal is shipped and unloaded.

W. J. O'Neil, sales manager, Chicago branch, Iron Fireman Manufacturing Co., in a letter to members of the Chicago coal trade, says:

Once in a while some one of our service men, called out on a trouble call, discovers that the user is not satisfied with the performance of his Iron Fireman because he is burning a cheap coal or a coal that is not properly sized and prepared.

We understand the coal man's problem. We know that often a buyer will insist on a cheap coal or thinks he knows best what size or kind of coal he should use.

But you know and we know how important it is that the stoker user get a good quality coal—important to the user, to you and to us.

High quality, suitably sized and prepared stoker coals are available from several fields, thanks to the foresight of responsible purchasers. Let's push those coals.

We urge buyers of Iron Fireman to ask their coal dealers for high quality coals. And we tell them why they should insist on it—for their own benefit.

For your own protection and to make sure that your customers are entirely satisfied with the performance of their stokers, recommend and sell quality stoker coals.

D. H. McMaster of the Bell & Zeller Coal Company, Chicago, says:

It has been our experience in merchandising stoker coal, that the public demands in addition to low ash and high heat stoker coal, a coal that will be dustless not only when it is placed in the customer's bin, but one that will remain dustless throughout the heating season.

From their studies on the use of stoker coals, M. P. Cleghorn and R. J. Helfinstine of Iowa State College, report that the smaller sizes (3/4 inch by 5/16 inch) gave the most evaporation per pound of coal. No great amount of difference was found between this size and the larger size nut coal tested, however, they explain in Bulletin No. 134.

BULK DENSITIES

Ralph A. Sherman of Battelle Memorial Institute, in Part II, of Technical Report No. 1, for Bituminous Coal Research, Inc., emphasizes the advantages of uniformity. In the conclusion of this report, he points out that:

The greatest effect of the size of coal on the operation of the stokers was the change in the rate of feed due to the difference in the bulk densities of the different sizes. To maintain uniform combustion efficiency, the rate of air supply must be changed as the rate of coal feed is changed. As a consequence, although one size of coal may perform as well as another when the stoker is properly adjusted, it is important that after the adjustments are made, the size be kept as uniform as possible.

The size of the coal supplied by the dealer in successive deliveries and charged to the stoker by the user from day to day can be kept more uniform the closer the limits of the size range of the coal.

Although the clearance between the feed tube and the core of the worm in present-day residential stokers, and, therefore, the maximum size of the coal fed are about 1¼-inch, stokers with larger clearances could be built. The difficulties with segregation would, however, increase with the increase in the size range.

SIZE RANGE

For this reason, the recent tendency toward narrowing the size range of stoker coal has merit. The production of a coal with a narrow size range practically always causes the producer difficulty in mechanical arrangements for the preparation and in profitable disposal of the resultant odd sizes. Care must be taken, therefore, that the narrowing of the size range is not carried to absurd limits or beyond the limit where the cost of preparation becomes greater than the gain in the performance.

Whether the top size chosen by a producer for his stoker coal is 1¼ inches, 1 or ¾ inch, or any other size, it is important that it be real and not nominal. That is, the screening should be so well done that the oversize is negligible. Occasional pieces of a 2- or 3-inch coal can cause serious difficulty from noise in crushing and from obstruction of the feed.

CAKING AND COKING

Sherman and E. R. Kaiser said, in a paper before the American Institute of Mining and Metallurgical Engineers:

> The two principal characteristics of a coal that determine its performance on small stokers are its caking and coking tendencies and its size range, and that these are, for many and probably for most bituminous coals, closely related.
>
> Conditions are favorable to coke formation, as is shown by the fact that coals normally considered free-burning, form coke in the stoker fuel bed. Practically all coals, therefore, form coke trees, but even rather strong coke formations cause little or no real difficulty in properly designed combustion chambers. The objections to coke trees are frequently entirely unsound.
>
> No sharp line of demarcation exists in the caking and coking characteristics, which divide suitable from non-suitable coals for stokers. The caking and coking tendencies may generally be reduced by the adjustment of the size range, which may include either reduction of the top size or removal of the fines from the coal, or both, but with many coals this is entirely unnecessary. When it is desirable, the size for removal cannot be categorically defined; it remains as yet a problem for determination on each individual coal, although with increased knowledge a more general answer is to be expected.
>
> Originally it was thought that only the truly free-burning coals could be used, but now a wide range of caking and coking coals is burned successfully. With a better understanding of the phenomena of caking and coking, it is probable that the design of retorts and tuyeres will be so modified as to make possible the successful use of even the most strongly caked coals.

Such is the comment of a representative group of men who have had considerable experience with stoker coal.

MANUFACTURERS' SUGGESTIONS

Some sort of instruction card or folder is shipped with every small stoker. These cards cover lubrication, regulation of the stoker, adjustment of controls, fuels, etc.

Anchor, for instance, includes a notice also about coal on the hopper lid. It reads:

> This Fire Chief Model Anchor Kolstoker is designed for burning the smaller sizes of coal. Coal should be used which will pass through a one-inch screen for best results.
>
> If larger coal is used noise from the crushing of the large pieces of coal passing through the worm will be noticeable.
>
> Properly sized prepared stoker coal with low ash content gives better results and requires less attention from the operator.
>
> High grade coal with low ash content is usually more economical to use than low-grade cheap coal.
>
> Use the better grades of prepared stoker coal for best results.

Kelvinator says: "Use a good grade of stoker coal. Bear in mind in selecting coal for use with the burner that the better grades of coal contain more heat units and over a period of time will prove more economical than cheap coal."

QUALITY—IMPORTANT FACTOR

Fairbanks-Morse tells its household stoker users that "The coal for use in a Fairbanks-Morse stoker may be buckwheat size, 3/8 by 1/2 inch, or one-inch prepared stoker screenings of a heating value of at least 11,500 B.t.u. per pound, and a low ash content of high fusion temperature. The quality of coal used is an important factor in securing complete satisfaction with a stoker."

Freeman says, among other things: "Make sure that coal does not contain too large a percentage of fines. Don't put anything in the stoker hopper except clean, small sized coal. Coal for this stoker should not exceed 1 1/4 inches in size."

"Use good fuel. Don't be tempted by cheap coal," says the Eddy Stoker Corporation, Chicago, in the first paragraph of their illustrated instruction card. "The Eddy Stoker will burn any stoker coal. But clean, dustless stoker coal burns hotter, uniformly, economically. It requires less attention. It gives more heat for less money. It costs less to use. Buy a good graded coal. Order a 5/16 by 10-mesh stoker coal. If not available, use 1-inch screenings with at least 35 per cent fines," they suggest.

GOOD COAL MOST ECONOMICAL

Auburn tells its household stoker users that "there are many prepared coals for domestic use which have the slack and dirt washed out or are treated to eliminate dirt in handling. The most desirable grade of coal is a high volatile, free-burning coal, preferably 1/4 inch to 3/4 inch in size, over a round screen. One and one-fourth inches may be used, but results in noise due to crunching. The washed coals are much more satisfactory than the chemically treated coals. (Good coal is the most economical.)" Such is the advice of another manufacturer as regards coal and its use in small stokers.

SELECTING STOKER FUEL

The Will-Burt Company of Orrville, Ohio, in its operating instructions goes into considerable detail as to selecting stoker fuel. In their instructions they say:

> The importance of selecting proper fuel for our Will-Burt stoker cannot be over-emphasized, because the coal you use will determine, to a great extent, the satisfaction you will obtain from your stoker.
>
> Heating plants vary widely in their characteristics and your coal should be selected, as nearly as possible, to fulfill the requirements of your particular heating system. For that reason it is often advisable to try several different coals, in small quantities at first, until you find the coal which best meets your requirements, considering burning qualities, price, etc. Many coal producers now furnish sized and dust-treated coal which is particularly suited to domestic use and is sometimes used on commercial installations.

The following figures will give you some idea of how the analyses of different coals may vary:

Heat value—10,000 to 15,000 B.t.u.

Ash content—3 to 15 per cent per lb.

Sulphur content—½ to 5 per cent.

Fusion temperature of ash—2,000 to 3,000 deg. F.

A properly sized, free-burning coal, high in heat units, low in ash and sulphur, and cleaned of all foreign materials which might obstruct the coal screw, provides the most trouble-free and satisfactory stoker operation and usually proves to be more economical, even at a greater cost per ton. Coke is very abrasive and is not recommended as a stoker fuel.

Coals best suited for domestic use should be 1 inch and under in size, high in heat units, low in ash and sulphur, with a fusion temperature of around 2,200 to 2,400 degrees, and cleaned of all tramp iron, pieces of wood, stones, etc.

If the coal is larger than 1 inch it will have to be crushed in passing through the coal tube. This creates an objectionable noise, causes undue wear on the stokers and increases the current consumption. If the lumps are too large to fall into the flights of the screw, they will ride on top and prevent the rest of the coal from feeding.

Normally a coal with a medium ash fusion temperature of from 2,200 to 2,400 degrees is to be recommended. If, however, the boiler or furnace is small or the radiation inadequate for the building, or both, so that the heating system must be crowded to carry the load, the fire box temperature will necessarily be higher and the fusion temperature should be proportionately higher.

With too low a fusion temperature ash melts, runs down into the burner pot and closes part or all of the air ports. The clinkers stick tightly to the tuyere or brickwork, often causing a pin to shear or the overload relay to "throw out." Clinkers under these conditions are difficult to remove. The remedy is to use coal with a higher fusion temperature. If the fusion temperature is too high the ash will not fuse into clinkers and obviously coal with a lower fusion temperature should be used.

When using a coal of high ash content it can be expected that more attention will be required in filling the hopper and removing the clinkers.

Link-Belt, in its operating instructions for smaller stokers, says:

The efficiency of the heating plant and the operation of the stoker is affected by the quality of coal used.

Best results are obtained with the use of a free-burning, non-coking, good quality of stoker coal. The largest lumps should not exceed 1¼ inches. The coal should contain about 40 per cent fines or small particles. The coal made up of yard sweepings or entirely fines is too dense to allow good air penetration.

When stoker coal is loaded into your bin, the fine and coarse parts separate, the coarse running to the sides and bottom of the pile. Therefore, when filling the stoker hopper take a shovelful alternately of the fine and the coarse coal.

The Morse Chain Company, manufacturers of the "Templux" stoker, says, in speaking of the "Kind of Coal to Use":

The Templux will burn any of the regular bituminous stoker coals. The best size is that which will pass through a 1-inch or ¾-inch mesh screen and be retained upon a ¼-inch mesh screen.

If lumpy coal is used without any fines or slack, it is difficult to control the forced air, with the result that the back pressure from the combustion chamber is apt to make the smoke back up through the loose coal into the hopper. On the other hand, a coal that is all slack will so retard the air supply that a spotty fire is apt to result, with the fire bed caked over to the point of smothering the fire, and causing the fire to burn back into the retort with possible damage to tuyeres.

Herman Winkler, U. S. Machine Corp., Lebanon, Indiana, in his instructions on coal selection, says:

> For domestic installations, a bituminous coal, low in ash (5 per cent or less) with an ash fusion temperature of 2,300 to 2,600 degrees F., and from 1¼ inches maximum to ⅜ inch minimum is ideal. However, nut and slack preparations may be used, although the percentage of fines should not exceed 25 per cent.
>
> In any case, oil treatment is recommended for dust elimination.
>
> A high quality coal will be most satisfactory and usually most economical. On small stokers the annual coal tonnage is relatively small and convenience is the primary object of the stoker.

Iron Fireman Mfg. Company, in its instructions for household stoker users, says:

> A good grade of prepared stoker coal gives best results with these units. The largest lumps should not be over 1 inch dimension and the fines ¼ inch dimensions, (or less) should not represent a high percentage of the total. Do not use coal that is extremely wet as it will not feed out of the hopper properly.
>
> Some dust treatments contain salts which cause the metal parts of the stoker to rust out in an abnormally short time. Coals that have been treated with these materials should be avoided.
>
> No paper, rags, sticks of wood, or rubbish should be put in the hopper. No glass, cans or metals should be thrown into the fire, as they will melt and close up the air slots in the firepot.

Combustioneer, in its operating instructions for its small stokers, discusses fuel in the second paragraph:

> The coal used in Combustioneer should be either prepared stoker coal (which most coal dealers can furnish) or screenings with a top size of 1¼ inches and containing 30 to not over 50 per cent fines below ⅛ inch. Consult your coal dealer or other stoker users as to the types of coal sold in your city that have given good satisfaction in stokers.
>
> Coal purchased at the lowest price per ton may not be the most economical. Low grades of coal are low in heat content and usually contain a high percentage of ash and other impurities which cause low efficiency and excessive clinker formation. It is recommended that the Combustioneer owner start with the best stoker coal available. After using such coal he will be in a position to make a comparison with lower grades if he desires to experiment with them.

Sears-Roebuck includes a large instruction chart with every household stoker shipped. The first paragraph in their large instruction sheet reads:

> Good stoker coal is more economical than ordinary grades, even though it may cost more per ton. We recommend prepared bituminous stoker coal, sizes ⅜ inch by 1¼ inches, or 1 inch by No. 10 mesh with fines (slack) washed out. If screenings are used, specify not over 1¼-inch size with not more than 30 per cent slack. Any coal of over 12,500 B.t.u. with ash fusing temperature of 2,200 degrees F. will be found satisfactory. Consult your local coal dealer. He is familiar with various kinds of coal available in your locality and can assist you in selecting the proper coal to use. Get him to show you mine analysis of coal.

Schwitzer-Cummins Company, in its Stokol bituminous stoker instruction card, says:

> For home installations, a bituminous coal, low in ash (5 per cent or less) with a fusing temperature approximately 2,500 degrees, size from 1¼ inches maximum to ⅜ inch is recommended.
>
> A washed, oil treated coal is recommended for dust elimination. Nut and slack preparations may be used. Lower quality fuels may be used on commercial installations. The percentage of fines (⅛ inch and lower) should not exceed 50 per cent of the total, with 20 per cent larger than 1 inch.
>
> The lowest priced coal per ton is not as a rule the cheapest, as the higher B.t.u. contents of the better fuels more than offsets the price difference. The lower the quality of fuel the more attention required to care for the fire.
>
> The Stokol dealer should advise the coal that has been used with satisfaction in other Stokols. Use good stoker coal for best results.
>
> Inspect coal as it is placed in the hopper for spikes, large nails, rocks, etc., which would lock the feed screw.

Norge Heating-Conditioning Division, Bog-Warner Corporation, Detroit, Michigan, gives this advice:

> Use prepared bituminous stoker coal size ⅜ by 1¼ inches with fine (slack) washed out.
>
> Where screenings are used, ask for not over 1¼-inch size with not over 30 per cent fines. A coal of 12,500 B.t.u. with ash fusing temperature of 2,200 to 2,500 degrees gives best results.
>
> Be sure coal is free from iron, spikes, stones, or similar hard matter, as they will jam the stoker. Do not put garbage, wood chunks or floor sweepings into hopper.

Sinker-Davis Company, manufacturers of the Fire-King Stoker, in their stoker instruction bulletin says:

> The question of fuel is a more or less difficult problem in some territories. An underfeed stoker is at its best with a free-burning bituminous coal, having some 25 to 35 per cent volatile with not over 10 per cent or less than 4 per cent of ash and a sulphur content down to .05 per cent, with an ash fusing at not less than 2,400 degrees F., and with non-caking combustion characteristics.
>
> It is impossible to tell from a coal analysis what a coal will do under fire. Coals with practically the same analysis have entirely different burning characteristics. Where the most accessible coal in any area is of a coking nature, certain changes in the method of burning have proven helpful. In general, restricting the grate surface will tend to reduce heavy coking. In all cases the depth of fuel bed should be increased from 8 to 10 inches, depending on the stoker size.
>
> It must be borne in mind that the smaller the stoker size, the more exacting it becomes in its fuel requirements. The frequency of attention is a factor in the selection of a suitable fuel that should not be overlooked.

CONCLUSIONS

Such is the evidence. It speaks for itself. Right or wrong, these printed instructions reflect the experiences of a representative group of stoker manufacturers. Much of what they say is incontrovertible—as anyone knows who has had experience in using several kinds or sizes of coal in a household stoker in his own basement.

With some of the assertions on a few of the instruction cards I do not agree. Nine years' experience and experimentation, in my own basement, with forty kinds and sizes of coal, five stokers and in as many furnaces and boilers, assure me that one can (but won't) burn literally any kind of coal. Except for the experimenters among us, however, the average individual soon orders that coal which works best, requires the least attention, offers the most in consumer satisfaction.

Price is secondary. Dustless treatment, ease of handling, are paramount. Cleanliness, not a coal analysis, is the number one factor.

Few manufacturers now predicate the operation of their stokers only on the use of a free-burning coal. Caking or coking, one can use them all. Whether we do or not depends, sometimes, on what else is available, and on what kind of a stoker we have. Geographic location is sometimes a factor, not always. To say that one "can't burn" a coking or caking coal is to put himself among that group of whom Barnum said "one is born every minute."

The experiences of other users, the recommendation of the stoker dealer or salesman—these are the factors, too, that count in the selection and purchase of household stoker coal.

Trick sizing is not necessary. Simplification and standardization of coal sizing, however, is most desirable, imperative. The needless multiplication of stoker coal sizes came about not through the demand of stoker manufacturers or stoker users. Competitive rivalries, one coal operator or district with another, or the desire to offer something the other fellow did not have, explain the innumerable sizes now offered.

Actually, as we have seen, stoker manufacturers aren't demanding split sixteenths in coal sizes. Economics of stoker manufacturing, however, set certain limits on feed worm sizes and consequently on maximum coal sizes. Bringing the limits of coal sizes closer together is desirable. Greater uniformity will reduce segregation and simplify the problem of air control. It will further consumer satisfaction. Oversized stoker coal is out. It's too noisy.

With the tremendous increase in preparation facilities at the mines, the customer can get what he wants at a reasonable price. The rapid increase in stoker sales is being more than paralleled by the increase in preparation facilities at the mines. There is no question about the market. It's what you make it. Give John Q. Public what he wants and the business is yours.